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Individual differences in working memory capacity and conscious processing do not explain explicit and implicit learning outcomes in physical education

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ABSTRACT

This study examined the effects of explicit versus implicit learning methods on motor learning and self-efficacy of 11-to 14-year old students ($n = 81$) practicing the basketball layup during physical education. The main aim was to test the effects of students' verbal working memory capacity (WMC) and propensity for conscious motor processing (CMP) on explicit and implicit learning outcomes. The students practiced basketball layups for three weeks (one session/week) during regular PE classes under practice conditions that either promoted explicit or implicit learning. Verbal WMC and CMP propensity were measured separately. At the posttest, students had significantly improved their layup performance and technique, and self-efficacy, but no differences were noted between the intervention groups (explicit vs. implicit). Students' verbal WMC and CMP propensity did not differentially predict the learning outcomes for the explicit or implicit learning groups. Therefore, in this PE setting, both explicit and implicit learning methods seemed to similarly improve movement skill. Further study is needed to examine under which conditions individual constraints such as verbal WMC and propensity for conscious processing influence the effects of explicit and implicit learning.

1. Introduction

Starting from the early nineties (Masters, 1992), explicit and implicit learning have become prolific research topics in motor learning, finding their ways into rehabilitation, sports and physical education (PE). In explicit learning, the learner uses declarative knowledge (e.g., facts and rules) to accomplish movement execution. Explicit learning involves cognitive stages and is dependent on working memory involvement (Kleynen et al., 2014). By contrast, implicit learning is considered to largely 'bypass' cognitive stages, as it relies less on verbal, declarative knowledge and working memory but more on automatic processes (Kal, Prosee, Winters, & van der Kamp, 2018; Kleynen et al., 2014). Explicit and implicit learning can be regarded as two ends of a continuum, with fully explicit learning (i.e., considerable build-up of declarative knowledge and great reliance on verbal working memory) at one end and fully implicit learning (i.e., absence of any accrual of declarative knowledge or verbal working memory involvement) at the other end

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(Kleynen et al., 2014, 2015). Explicit learning is usually accomplished by providing relatively detailed prescriptive, step-by-step instructions which the learner can employ to approximate the desired movement execution. These instructions predominately focus on the consecutive body movements that have to be made (i.e., evoke an internal focus of attention). Contrary to such prescriptive learning methods, a more implicit mode of learning can be evoked by error minimizing learning (e.g., Maxwell, Masters, Kerr, & Weedon, 2001), analogy learning (e.g., Liao & Masters, 2001) and learning with an external focus of attention (e.g., Wulf, 2007). For an overview of these methods, see Kal et al. (2018) and Kleynen et al. (2014, 2015).

The characteristics of implicit learning seem conducive for motor learning in children - and therefore in PE. That is, as working memory continues to develop into young-adulthood (Huizinga, Dolan, & van der Molen, 2006), available working memory resources may limit children's ability to benefit from (working memory reliant) explicit learning (Masters, van der Kamp, & Capio, 2013). Also, implicit learning methods (especially errorless or error-minimizing learning) are suggested to strengthen feelings of self-efficacy in children (see Van der Kamp, Duivenvoorden, Kok, & van Hilvoorde, 2015), which is an important prerequisite for enhancing participation in future movement activities (Gao, Lochbaum, & Podlog, 2011; Hagger, Chatzisarantis, & Biddle, 2001), a key intended outcome of PE (Van der Palen, 2020). However, notwithstanding its potential benefits, little research has been conducted on the effects of implicit learning methods in children. Specifically, studies on the effects of error minimizing learning and analogy learning methods are scarce. Van Abswoude, Mombarg, de Groot, Spruijtenburg, and Steenbergen (2021) conducted a systematic review on the state of evidence of studies on implicit and explicit motor learning methods in 4 to 12-year-old typically developing children and children with developmental disorders. They included 25 studies, from of which four studies included error minimizing learning, three studies applied analogy learning and eighteen studies administered external focus instructions as implicit learning methods. Van Abswoude et al. (2021) concluded that implicit learning methods were just as effective, or in some cases more effective, compared to explicit learning methods to improve motor performance in children. Furthermore, they reported that most studies showed a large standard deviation in the amount of motor learning, indicating individual differences in the effectiveness of both implicit and explicit learning methods. Most of the included studies in Van Abswoude et al. (2021) were conducted in controlled laboratory settings, which may limit transfer of findings to real-life settings such as PE (see also Van der Kamp et al., 2015). Further, as also argued by Van Abswoude et al. (2021), for PE it is relevant to ascertain how individual constraints influence the effectiveness of explicit and more implicit learning methods, such that PE teachers can deliberately choose learning methods to optimize motor learning and self-efficacy.

One of the individual constraints that may influence the extent to which students profit from explicit or implicit learning methods in PE is their verbal working memory capacity (WMC). Kok, Kal, van Doodewaard, Savelsbergh, and van der Kamp (2021) found that the effects of explicit and implicit learning methods in PE in special education depended on the verbal WMC of the participating 9-to-13 years old students with special educational needs. In this study, PE teachers provided the students with instructions and feedback on balancing technique. Verbal WMC was found to positively predict balancing improvements and increases in perceived competence of students who received explicit instruction and feedback (i.e., explicit internal focus instructions and feedback). Further, verbal WMC was negatively associated with increases in balancing performance in students who received implicit methods of instruction and feedback (i.e., analogies and external focus instructions). Also, a laboratory study of Buszard et al. (2017) showed that 8 to 10-year-old children with high verbal WMC demonstrated consistent improvements in a basketball shooting task in which they received multiple internal focus instructions (which promote *explicit* learning). Contrarily, children with low verbal WMC showed deteriorated basketball performance under the same practice conditions.

While the abovementioned studies suggest that children with greater verbal WMC may benefit more from explicit, rather than implicit learning methods, many other laboratory studies have failed to find an association between verbal WMC and explicit learning gains in children (Brocken, Kal, & van der Kamp, 2016; Krajenbrink, van Abswoude, Vermeulen, van Cappellen, & Steenbergen, 2018; Van Abswoude, Nuijen, van der Kamp, & Steenbergen, 2018; Van Abswoude, van der Kamp, & Steenbergen, 2019; Van Cappellen-van Maldegem, van Abswoude, Krajenbrink, & Steenbergen, 2018). A possible explanation for these inconsistent findings concerns the relative strain of the included interventions on verbal WMC. In the studies that did not find an association (Brocken et al., 2016; Krajenbrink et al., 2018; Van Abswoude et al., 2018, 2019; Van Cappellen-van Maldegem et al., 2018), children were provided with a limited number of instructions (maximum of 1–3 instructions) before every block of 5–20 trials. The relative strain on verbal WMC was likely higher for participants in Buszard et al. (2017) who received multiple (i.e., five) instructions before every practice block, and also for the participants in Kok et al. (2021) who received 2–4 instructions before every practice session and prescriptive feedback before every attempt. Also, participants in Kok et al. (2021) performed the balancing task in an actual PE lesson, instead of a laboratory. This setting may have put extra demands on working memory to avoid distraction and overload in a busy gym hall with active teachers and peers. Moreover, the participants in Kok et al. (2021) had special educational needs and exhibited limited working memory resources.

Another constraint that may partly explain differences in the effectiveness of explicit or more implicit learning methods in PE is the learner's propensity for conscious control of movement. Individuals differ in their tendency to use conscious, explicit, rule-based knowledge to control their movements (see Masters & Maxwell, 2008). Possibly, explicit learning methods suit children with high propensity for conscious control best, whereas more implicit learning methods match with children who demonstrate low propensity for conscious control. In line with this hypotheses, Tse and van Ginneken (2017) demonstrated that 10-year-old children with high conscious control propensity showed greater dart throwing accuracy in transfer (i.e., increased distance towards the target) and retention if they had been provided with internal focus instructions during practice, whereas children with low conscious control propensity displayed better accuracy at transfer and retention when they received external focus instructions during practice. Van Duijn, Thomas, and Masters (2019) examined the relation between conscious control propensity and motor performance of 13-year-old students after an explicit (using rule-based movement instructions) and a more implicit (using a movement analogy) learning phase in a PE setting in which students practiced golf chipping. Students with low(er) conscious control propensity displayed more accurate chipping after practicing with the analogy. Together, the findings of Van Duijn et al. (2019) and Tse and van Ginneken (2017) do suggest that it may be beneficial for PE teachers to match learning methods to habitual inclinations of students to consciously control movements.

In recap, both verbal WMC and a propensity for conscious control may be individual constraints that partly explain differences in explicit and implicit learning gains. Buszard, Farrow, Zhu, and Masters (2013) demonstrated that verbal WMC and propensity for conscious control were significantly related in 8 to 12-year-old children, which may suggest that greater ability to hold and manipulate information (i.e., high verbal WMC) increases the opportunity for consciously controlling movement execution (i.e., high propensity for conscious control). If we expand this premise, this may mean that the effects of explicit and implicit learning in PE result from an interaction between the learning method chosen by the teacher (i.e., task constraints), the verbal WMC and the propensity for conscious control (i.e., both individual constraints). Hence, students may profit from explicit learning methods, if they tend to consciously control movement execution and their verbal WMC allow them to do so. Vice versa, students who don't tend to consciously control their movements and/or have limited verbal WMC may be best served with more implicit learning methods.

To test the above ideas, we examined the effects of explicit and more implicit learning methods on children's motor learning and self-efficacy. The main aim was to assess how individual differences in verbal WMC and conscious control propensity influenced the effects of explicit and implicit learning methods. To ensure a representative study, the experiment was conducted in regular PE lessons. Furthermore, as opposed to laboratory studies and in line with (educational) practice (Poolton & Zachry, 2007), and our previous work (Kok et al., 2021), we chose to use a blend of implicit learning methods (i.e., errorless learning, analogy learning, learning with external focus instructions) to evoke implicit learning. A primary reason is that within educational practice, sticking to one specific type of intervention only would lead to quite artificial and constrained teaching practice. PE teachers would be limited in their options to guide students' learning when they are only allowed to use e.g., external focus instructions. Allowing a blend of methods that target different aspects of movement practice (i.e., task difficulty through errorless learning, and instructions/feedback through external focus and analogy learning) gives teachers options to provide more flexible, tailored guidance. Also, implicit learning methods are very easily combined in practice (Poolton & Zachry, 2007). Thus, blending these different methods will help create a learning environment that optimizes the intervention's efficacy for inducing implicit learning.

2. Material and methods

2.1. Participants

A priori power-analysis (G*Power 3.1.9) revealed that for a RM-ANOVA with within-between interaction, two groups, and two measurements, a minimum of 34 participants in total would be needed to detect a moderate effect of learning method on learning outcomes ($\alpha = 0.05$, $\beta = 0.80$, expected $r = 0.50$, effect size $f = 0.25$). Furthermore, for a two-tailed multiple regression model with four predictors (i.e., group, verbal WMC, visuospatial WMC, and CMP propensity), a minimum of 77 participants would be needed to be able to detect a significant moderate ($f^2 = 0.15$) improvement in R^2 when adding three two-way interaction terms (verbal WMC by group, CMP propensity by group, CMP propensity by verbal WMC). For the resulting regression model with seven predictors, 55 participants would be needed to be able to detect a significant moderate ($f^2 = 0.15$) improvement in R^2 when adding the three-way interaction term (verbal WMC by CMP propensity by group).

We recruited first-year students from four classes of a secondary school located in a large Dutch city. In the Netherlands, all schools are government funded, there is no distinction between private and public schools. Of these four classes of students, one class of students received higher general secondary education, one class received pre-university education, and two classes were in a transitional year. At the end of a transitional year, students would receive either pre-university education or higher general secondary education in their remaining secondary school years. Although (small) differences in educational level were present between these classes, all classes followed the same PE program. The protocol of the study was approved by the local university's ethics committee (Scientific and Ethical Review Board, Faculty of Behaviour & Movement Sciences, Vrije Universiteit Amsterdam, VCWE-2015-145). We approached all parents of the students of the four classes (110 students) for passive consent and all students for active consent. We gained active consent of 88 students. For two of these students we did not gain passive consent[1] from their parents. Therefore, 86 students (40 boys and 46 girls, $M_{age} = 12.80$ years, $SD_{age} = 0.47$ years) participated in this study.

2.2. Task and apparatus

The to-be-learned task was to throw a basketball via the backboard into the basket (i.e., make a bankshot) with a layup technique (Fig. 1). Learning a layup is part of the first year PE curriculum in secondary education. Hence, students had not experienced performing layups in PE before. While we did not specify exclusion criteria regarding prior basketball experience outside PE, we did record if students had any such experience. A standard basketball installation (Nijha) was used, with the height of the hoop adjusted to 2.60 m. The starting position was marked with a cone on the right (for right-handed students) and on the left (for left-handed students) of the basket (Figs. 1 and 2). From that point, students had to start from a standstill position with their two stepped approach (right-left for right-handed students; left-right for left-handed students) towards the basket. At pre- and posttests, performance was video recorded with a Fuji film camera (finepix XP60), see Fig. 2 for camera positions.

[1] In this context, passive consent refers to parents having to actively opt-out if they objected to their child participating.

Fig. 1. Snapshots of the to-be-learned task (i.e., for right-handed students) executed by the mastery model.

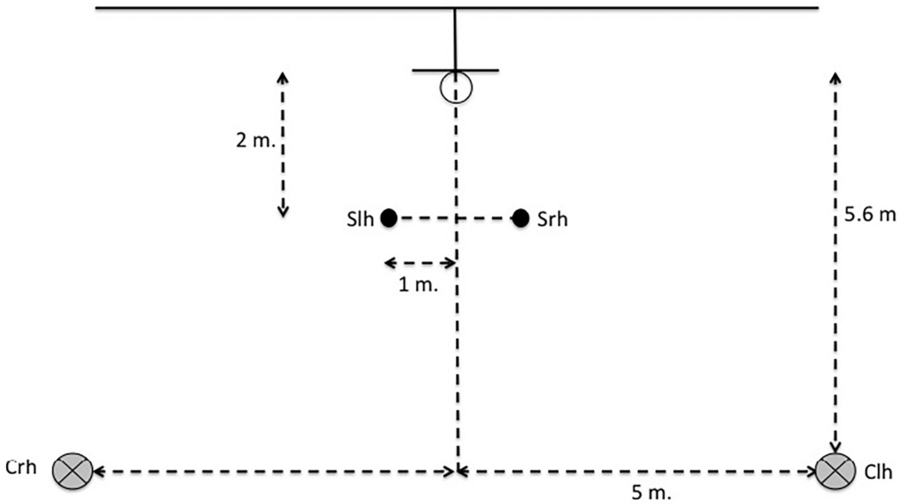


Fig. 2. Schematic top view of the layup situation, with Slh: starting point left-handed students; Srh: starting point right-handed students; Crh: camera position for recording right-handed students; Clh camera position for recording left-handed students.

A scoring system for layup outcome (i.e., scores ranging from 0 to 5) was developed in cooperation with the schools' PE teachers (Fig. 3). Furthermore, a rating scale for layup technique (i.e., scores ranging from 0 to 10, see Table 1) was designed together with the PE teachers and ball sports specialists from Windesheim Applied University of Physical Education and The Hague Applied University of Physical Education. Items of the rating scale for layup technique represented the intended learning outcomes of the practice sessions. To assess reliability of the designed rating scale, a research assistant and the experimenter independently rated 50 randomly selected recorded trials from pre- and posttest. A single-measures, 2-way mixed, absolute-agreement ICC indicated good interrater reliability (ICC = 0.837, 95%CI [0.658,0.916]).

Self-efficacy scales were developed in accordance with Bandura's (2006) guidelines for assessing self-efficacy beliefs in children. Students had to score the strength of their efficacy beliefs on a 10-point scale, ranging in single unit intervals from 0 ("Cannot do"); to intermediate degrees of assurance, 5 ("Moderately certain can do"); to complete assurance, 10 ("Highly certain can do"). To support

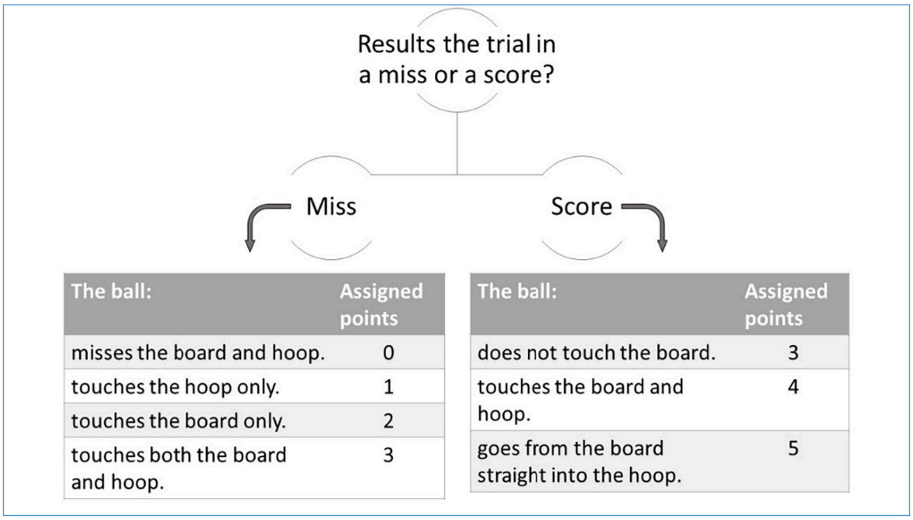


Fig. 3. Scoring system for layup outcome.

Table 1
Rating scale for layup technique.

Footwork and positioning towards the basket The student shows:	No (0 points) /yes (1 point)
1. a two-stepped approach towards the basket with the ball in the hands.	
2. right-left (in case of a right sided approach) or left-right (left sided approach) steps.	
3. good positioning towards the basket (i.e., a close, but not too close approach in which the student has to lean backwards to throw).	
4. fluent step-step-jump transitions.	
5. a relatively high velocity of movement.	
Jump *The student shows:*	
6. a flight phase.	
7. that the knee of the outer leg is brought forward and up.	
8. a powerful, high jump.	
Throw *The student shows:*	
9. a two-handed guidance of the ball upward, ending with the ball in the right (right sided approach) or left (left sided approach) hand.	
10. a guidance of the ball towards the board that is as long as possible (i.e., extended reach)	

understanding, circles with progressively larger size accompanied the numeric scale with size gradations representing increasing confidence. On the basis of this rating scale, students rated their confidence in layup performance for three items ("I can score one out of two trials"; "I can score two out of two trials"; "I can perform the layup in a similar manner as the girl in the video", i.e., mastery model, see Fig. 1). Self-efficacy score was obtained by summarizing the scores on these three items (i.e., scores ranging from 0 to 30).

WMC was measured using two subtests of the Dutch and second version of the Automated Working Memory Assessment (AMWA-2-NL; Alloway, van Berkel, & van der Zwaag, 2015). Verbal WMC was measured with the listening recall test. In this test, students listened to spoken statements. After every statement, students had to indicate whether the statements were true or false. Furthermore, after a (gradually growing) set of statements, students had to recall the final words of the statements in the same order as they were presented. Besides verbal WMC, visuospatial WMC was also measured. Verbal and visuospatial WMC can be considered as distinct, but correlated constructs in children (Gathercole, Pickering, Ambridge, & Wearing, 2004). As such, if we found that the relation between learning method (explicit vs implicit) and motor learning outcomes was significantly influenced by verbal WMC, we needed to be able to control for any potential concomitant differences in visuospatial WMC (as we also did in Kok et al., 2021). Visuospatial WMC was assessed with the spatial recall test. In this test, students were presented with two shapes of which they had to indicate whether they were the same or different (i.e., a mirrored image). Also, every shape on the right side exhibited a red dot at a specific position. After a growing set of presented shape-pairs, student had to recall the positions of the red dots in the same order as they were previously presented. The listening- and spatial recall subtests have been demonstrated to have a good test-retest reliability ($r = 0.88$ and $r = 0.79$, respectively; Alloway et al., 2015). Both subtests' raw scores were used for analyses.

The Dutch version of the MSRS for children (MSRS-C-NL, Van Abswoude et al., 2018) was used to assess CMP propensity. Confirmatory factor analysis from data of 244 7 to 13-year-old Dutch children has shown that the MSRS-C-NL has good psychometric properties (Van Abswoude et al., 2018). The questionnaire consists of 10 questions, with 5 questions for measuring CMP propensity (e.g., "Do you try to find out why a certain movement did not go well?") and 5 questions for measuring movement self-consciousness (e.g., "Do you know what you look like when you move?"). The scale has a 4-point Likert scale: "never"(1 point), "sometimes"(2 points), "often"(3 points), and "always"(4 points). CMP and movement self-consciousness are two different types of internally focused attention, with high MS-C reflecting a tendency towards conscious *monitoring* of movements and high CMP towards a tendency to consciously monitor *and control* movements (see Van Ginneken et al., 2017). As PE teachers try to adapt the way students *control* their movements by means of providing explicit or more implicit learning methods, CMP propensity may be the most relevant factor in explaining the differential effects of explicit and implicit learning methods in PE. Therefore, the summed points scored on the five CMP propensity questions (i.e., range of 5–20) were used for analyses.

To measure the self-reported use of declarative knowledge during posttest, students filled in a questionnaire. This questionnaire started with the open-ended question: "Where did you pay attention to while you were performing the layup?". The number of reported rules on movement technique were counted and used for analyses. Subsequently, students had to rate five consecutive statements on the degree to which they focused on their: foot placement, position towards the basket, the way they performed their jump, the way they performed their throw, and the spot they pointed at (e.g., "I focused a lot on the way I jumped"). Each of these five statements was rated on a 10-cm continuous scale from 'highly disagree' (0 cm/points) to 'highly agree' (10 cm/points), which resulted in five focus rates ranging between 0 and 10 points.

2.3. Procedure and design

The study was embedded in regular PE lessons of the four classes. According to the school timetable, every experimental class had their PE lesson (i.e., with a duration of 90 min) planned simultaneously with another experimental class, with the lessons taken place in two adjacent gym halls. During lessons with experimental activities, the PE-teachers, teacher intern, and experimenter worked tightly together in organizing the PE lessons of the two classes and conducting the experiment (see Table 2 for their roles and responsibilities). This permitted that the experimental setup was only needed in one gym hall (gym hall 1), and that students who were assigned to different experimental groups could not observe each other's activities during the intervention because they were doing non-experimental PE activities in the adjacent gym hall (gym hall 2). The experiment was designed by the first author (experimenter) and the second author (leading PE teacher). During the design process, the leading PE teacher kept the other PE teachers informed and asked for their input. In a meeting before the start of the experiment, the experimenter and PE teachers discussed and clarified the experimental roadmap to the involved PE teachers and intern.

In the first week of the experiment, the leading PE teacher and the experimenter informed the students on the experiment during a regular PE lesson, after which, the students decided whether to participate in the experiment. If there was consent from the student and parents, the student completed the MSRS-C-NL (Van Abswoude et al., 2018) together with questions that retrieved their preferred throwing arm and whether they were or had been members of a basketball club during leisure time. The study design consisted of a pretest (week 2), three practice sessions (week 3, 4, and 5, respectively), and a posttest (week 6). In week 7 during school time, the students were called one-by-one to the experimenter to perform the listening- and spatial recall subtests of the AMWA-2-NL (Alloway et al., 2015).

During pre- and posttests, half of gym hall 1 was exploited for the experimental task. Before the test, the leading PE teacher instructed the students (per half of the class) that they were going to perform layups, that a layup is an effective way to score in basketball if you have to cover a distance towards the basket, and that they should try to score by emulating the girl in the video (see Fig. 1 for screenshots). After this introduction, the students came to the experimental task one-by-one. First, every student watched the mastery model on video in which the layup was performed in the way that corresponded with the handedness of the student. The student watched the video twice: once in normal speed and once in slow-motion. Because students were novices, we anticipated they would need more time to observe the complex two stepped approach towards the basket. This was based on studies that showed that slow presentation speed enables perception of complex contents in novices (e.g., Jarraya et al., 2019; Meyer, Rasch, & Schnotz, 2010;

Table 2
Involved persons with their roles and main responsibilities.

Persons/roles	Main responsibilities
Experimenter	• Designing the experiment together with the leading PE teacher • Supervision of experiment (week 2–6; gym hall 1) • Guide students through pre- and posttest, collect data (week 2 and 6; gym hall 1) • Carrying out working memory assessments (week 7)
Leading PE teacher	• Designing the experiment together with the experimenter • Organization during experimental PE lessons (manage flow of student groups, time, materials; week 2–6; gym hall 1 and 2)
Intervention PE teacher	• Guide students during experimental interventions (i.e., practice sessions; week 3–5; gym hall 1) • Guide students during non-experimental activities (week 1 and 6, gym hall 1)
Non-experimental PE teacher or teacher-intern	• Guide students through non-experimental activities (week 1–6, gym hall 2)

Rekik et al., 2021). Consecutively, the student filled in the self-efficacy questionnaire and performed two layups that were video recorded. Only during the posttest, students completed the questionnaire for self-reported use of declarative knowledge immediately after performing the layups. Based on the video recordings, layup outcome and layup technique were scored according to the scoring systems (Fig. 3 and Table 1). The video reviewers were blind to the participants and their groups. For both outcome measures, scores of the two layup trials were summed and used for analyses (i.e., scoring range layup outcome: 0–10; layup technique: 0–20).

After the pretest, students of every class were ranked according to their layup outcome scores. Next, they were alternately allocated to the explicit learning method (i.e., explicit) group or the implicit learning method (i.e., implicit) group to ensure similar pretest layup levels between experimental groups. During week 2–6, the PE lessons consisted of two rounds and were organized according to experimental group instead of class. Thus, when one experimental group (among 20 students) was having a layup practice session in gym hall 1 guided by the intervention PE teacher (a 48-year-old male with 26 years of teaching experience) in accordance with its experimental condition, the other experimental group and the students who did not participate in the study were doing non-experimental PE activities in gym hall 2 with guidance of the non-experimental PE teacher or teacher intern. After round 1, the experimental groups switched activities.

The intended learning outcomes per practice session were the same for both experimental groups. Practice session 1 focused on footwork and positioning towards the basket (for intended learning outcomes, see Table 1: items 1–5) and practice session 2 focused on the jump and throw (for intended learning outcomes, see Table 1: items 6–10). Practice session 3 focused on pointing on a specific spot on the backboard, from which the ball was expected to bounce into the basket (i.e., increased layup outcome, see Fig. 3). Every practice session started with instructions for the whole group (approximately 20 students) from the intervention PE teacher concerning the focus points of the specific practice session and, during practice session 2 and 3, a recap of instructions from former practice sessions. After going over these instructions, the intervention PE teacher demonstrated the layup twice from each starting point (i.e., for left- and right-handed students). Next, the students were divided over four layup stations and started to practice. The intervention PE teacher supervised the four layup stations and provided individual motivational and/or information feedback when he thought it was desirable. In this practice situation, every student performed 20 layups. At the end of each practice session, every student watched the video model twice individually and performed two more layups with task-constraints that resembled the pre- and posttest. Thus, if students completed all three practice sessions, they had practiced 66 layups in total.

Although the intended learning outcomes and structure of practice sessions were the same for both experimental groups, the exact instructions, layup practice situations and verbal guidance during practice differed between the two experimental groups. The explicit group received instructions and feedback with a (predominantly) internal focus of attention (e.g., 'Jump from your left leg', and 'Your right knee goes up simultaneously with your right hand') and practiced the exact to-be-learned task (i.e., similar task constraints as in pre- and posttest). The implicit group, however, received instructions and feedback formulated as an external focus instruction (e.g., 'Try to hit the big rectangle with the ball' and 'Push the ground powerful away') and/or analogy (e.g., 'Pretend as if you are a jumping jack toy on the side of the ball'). In addition, task-constraints were manipulated to implement an error-minimizing learning method. In the first practice session, for example, a red and a yellow circle on the floor marked the locations for foot placement (i.e., Red circle/Right foot; yeLLow circle/Left foot). The teacher removed these circles during the course of the second practice session. Furthermore, students were instructed to hit rectangles of different sizes instead of the basket during the first practice session. The size of the rectangle depended on previous scores (i.e., students proceeded with a smaller rectangle) or misses (i.e., students proceeded with a larger rectangle). See Appendix A for a detailed overview of the applied explicit and implicit learning methods per group and per practice session.

2.4. Statistical analyses

All statistical procedures were performed using IBM Statistics SPSS, version 26. Statistical significance level was fixed at $p = .05$.

First, it was checked whether stratification was successful to identify potential confounding variables that should be accounted for in the regression analyses. Therefore, separate independent t-test or Mann Whitney U tests (i.e., depending on data distribution) and a Chi-squared test were conducted to examine whether the two experimental groups differed on age, verbal and visuospatial WMC, CMP propensity, layup outcome and technique at pretest, self-efficacy at pretest and gender distribution. To check whether the explicit and implicit learning interventions had been successful, we assessed whether these two experimental groups differed in the number of self-reported movement rules and focus rates at posttest, using separate one-way independent t-tests or Mann Whitney U tests.

Next, three separate 2(Group: E, I) x 2(Test: pretest, posttest) ANOVAs with repeated measures on the second factor were performed to compare the two groups' improvements in layup outcome and –technique, and self-efficacy. Effect sizes were calculated with partial eta squared (η_p^2) with values of 0.01, 0.06, and 0.14 considered as small, moderate, and large effect sizes (Cohen, 1988).

Finally, two three-stepped hierarchical regression analyses were conducted with pre- to posttest improvements in layup outcome and layup technique serving as dependent variables, respectively. For these regression analyses, discrete values of the dependent variables were centered on the mean. Main effects of group, verbal and visuospatial WMC's and CMP propensity on performance improvements were examined by including these four variables in the first step. In the second step, the three two-way interaction terms (verbal WMC by group, CMP propensity by group, and verbal WMC by CMP propensity) were added. With this second step, we examined whether the effects of group were influenced by verbal WMC and CMP propensity and whether these two variables interacted in predicting performance improvements. In the third step of the regression analyses, the relation between verbal WMC, CMP propensity, and group was further explored by assessing whether the effects of group on layup outcome or technique were influenced by CMP propensity and verbal WMC. Therefore, the three-way interaction term (verbal WMC by CMP propensity by group) was added in this step.

The interaction terms were interpreted as relevant if they significantly improved model fit (R^2). Although separate interaction terms were considered as significant at $p < .05$, we further examined the relation between the interaction term and dependent variable at $p < .10$ by performing a moderator analysis with the Johnson-Neyman technique. For all regression analyses, the assumptions of homoscedasticity (i.e., by inspecting the standardized residuals by standardized predicted values plot), lack of multicollinearity (VIFs<1.6, tolerances>0.6), and normal distribution of errors (e.g., non-significant Kolmogorov-Smirnov) were verified.

3. Results

3.1. Group characteristics

Three students were absent at the pretest and/or posttest and were excluded from analyses. Two other students were also excluded from analyses; they were both active youth members of a basketball club and were identified as outliers with respect to basketball technique scores at pretest, with scores of 19/20 and 20/20, respectively. Of the remaining 81 students, 17 students (i.e., 9 students from the explicit group and 8 students from the implicit group) missed one out of the three practice sessions. Since absence between groups did not differ, and it is quite common that are students occasionally miss PE classes, all of the remaining 81 students were included in analyses. Group characteristics are shown in Table 3.

Unexpectedly, the explicit and implicit group differed significantly on verbal WMC, U = 473, $p = .02$. Furthermore, a small -but non-significant- difference between the two groups was present on self-efficacy at pretest, t(79) = 1.96, $p = .05$. Self-efficacy at pretest correlated significantly with increases in self-efficacy from pretest to posttest, $r = -0.32$, $p < .01$, but not with increases in layup outcome and layup technique from pre- to posttest ($r = 0.07/-0.19$ respectively). Verbal WMC did not correlate with improvements in layup outcome or technique from pre- to posttest ($r = 0.09/0.14$ respectively), neither with increases in self-efficacy from pre- to posttest, $r = 0.04$. Therefore, verbal WMC and self-efficacy at pretest were not included as covariates in later ANOVA analyses, and self-efficacy at pretest was not included in later regression analyses of layup outcome and layup technique (n.b., in accordance with the planned statistical analysis, verbal WMC was included in the regression analyses).

3.2. Intervention check

Table 4 shows that although the explicit group reported a higher number of applied movement rules and higher reported focus rates on most movement aspects compared to the implicit group, significant differences were only present for focus rate of foot placement, U (80) = 616, $p = .04$, and focus rate for the throw, t(78) = 1.80, $p = .04$.

3.3. Effects of guidance method on motor performance and self-efficacy

Fig. 4 shows clear increases in layup outcome, −technique, and self-efficacy scores in the explicit and implicit groups, without distinct differences between groups. Hence, a RM-ANOVA revealed a main effect for test for layup outcome, F(1,79) = 27.65, p < .01, $\eta_p^2 = 0.26$. No significant effects for group, F(1,79) = 0.06, $p = .82$, $\eta_p^2 = 0.001$, or group x test, F(1,79) = 0.26, $p = .61$, $\eta_p^2 = 0.003$, were found. Similarly, a main test effect was found for layup technique, F(1,79) = 147.14, p < .01, $\eta_p^2 = 0.65$, without significant effects for group, F(1,79) = 0.25, $p = .62$, $\eta_p^2 = 0.03$, or group x test, F(1,79) = 0.81, $p = .37$, $\eta_p^2 = 0.01$. Finally, a significant main test effect was also present in self-efficacy, F(1,79) = 69.25, p < .01, $\eta_p^2 = 0.47$, again without significant effects for group, F(1,79) = 3.45, $p = .07$, $\eta_p^2 = 0.04$, and group x test, F(1,79) = 0.15, $\eta_p^2 = 0.002$.

3.4. Relationships with WMC and CMP propensity

Table 5 summarizes the results of the two separate hierarchical regression analyses in which we examined the relationships of

Table 3
Group characteristics.

	Explicit Group (N = 42)	Implicit Group (N = 39)	Value Test Statistic	p-value
Gender	24 girls, 18 boys	20 girls, 19 boys	$X^2(1) = 0.28$	0.60
Age (years)	12.78 ± 0.50	12.80 ± 0.44	U = 859	0.71
Verbal WMC (raw score)	19.55 ± 4.03	17.78 ± 3.26	U = 473[#]	**0.02**
Visuospatial WMC (raw score)	24.16 ± 5.98	24.54 ± 5.57	U = 728[#]	0.79
CMP propensity	12.40 ± 1.91	11.90 ± 2.58	U = 751	0.51
Layup outcome at pretest	5.57 ± 2.15	5.64 ± 2.30	U = 821	0.99
Layup technique at pretest	9.33 ± 4.17	8.64 ± 3.43	t(79) = −0.14	0.42
Self-efficacy at pretest	13.38 ± 6.32	10.67 ± 6.09	t(79) = 1.96	0.05

[#] $n_{missing} = 7$, Kolmogorov-Smirnov analyses indicated that layup technique and self-efficacy at pretest scores were normally distributed. Therefore, independent *t*-tests were conducted to test whether experimental groups differed on layup technique and self-efficacy at pretest. However, non-normal distributions were present for age, D(81), 0.10, $p < .05$, verbal WMC, D(74) = 0.14, $p < .01$, visuospatial WMC, D(75) = 0.16, p < .01, CMP propensity, D(81) = 0.11, p < .05 and layup outcome at pretest, D(81) = 0.13, $p < .01$. Non-parametric Mann Whitney *U* tests were used for the non-normally distributed variables. Bold values denote $p < .05$.

Table 4
Reported number of rules and focus rates per experimental group.

Group	Number of rules##		Focus rate foot placement#		Focus rate position towards basket#		Focus rate Jump#		Focus rate Throw#		Focus rate Pointing#	
	M ± SD	p	M ± SD	p	M ± SD	p	M ± SD	p	M ± SD	p	M ± SD	p
Explicit	2.3 ± 1.3	0.19	4.3 ± 3.2	**0.04**	4.8 ± 2.9	0.16	4.4 ± 2.9	0.14	4.3 ± 3.1	**0.04**	3.6 ± 4.5	0.43
Implicit	2.0 ± 1.0		3.0 ± 3.0		4.1 ± 2.9		3.8 ± 3.0		3.2 ± 2.4		3.7 ± 3.4	

#$n_{missing} = 1$, ##$n_{missing} = 2$, Focus rates on the position towards the basket and the throw were normally distributed. However, non-normal distributions were present for number of rules, $D(79) = 0.20$, $p < .01$, and focus rates of foot placement, $D(80)$, 0.15, $p < .01$, jump, $D(80) = 0.12$, $p < .01$, and pointing, $D(80) = 0.19$, $p < .01$. Hence, depending on distribution, one- way independent *t*-tests and Mann Whitney *U* tests were used to examine whether the explicit and implicit groups differed in reported number of applied rules and reported focus rates. Bold values denote $p < .05$.

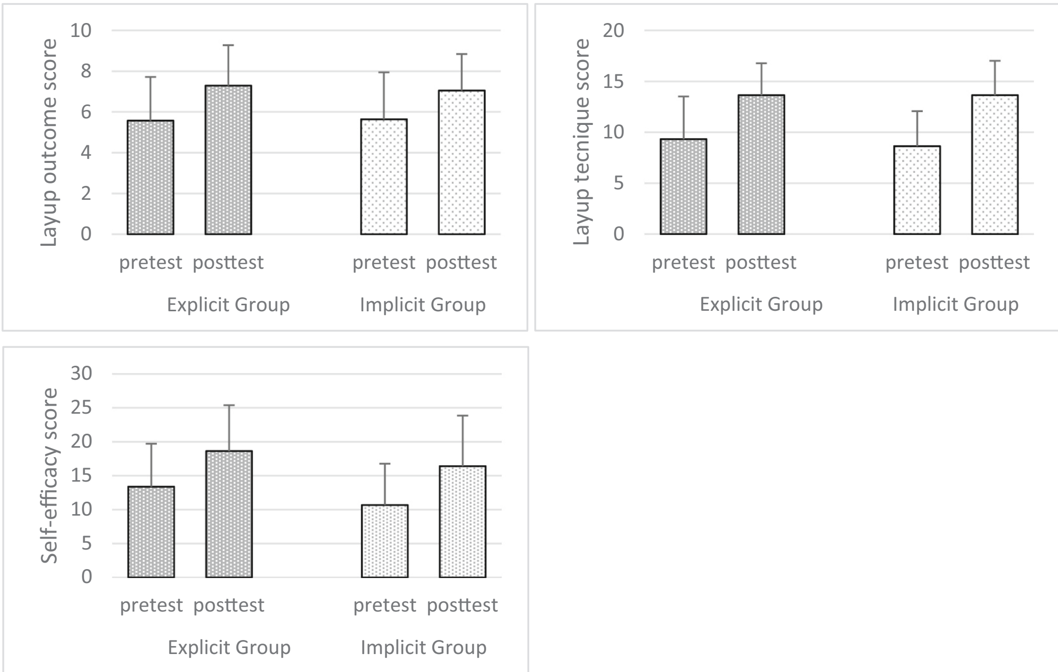


Fig. 4. Layup Outcome, Layup Technique, and Self-Efficacy Scores as a Function of Group and Test.

learning method (i.e., group), verbal WMC, and CMP propensity with improvements from pre- to posttest in layup outcome (model 1) and layup technique (model 2).

Improvement in layup outcome was not predicted by group, verbal WMC, visuospatial WMC, or CMP propensity. Inclusion of the three interaction terms (verbal WMC by group, CMP propensity by group, and verbal WMC by CMP propensity) in step 2 did not lead to a significant prediction model, nor did inclusion of these interaction terms lead to improvement in model fit. Furthermore, inclusion of the three-way interaction term (verbal WMC by CMP propensity by type of guidance) did not lead to a significant prediction model nor to significant increases in model fit.

For layup technique, similar results were found. However, in step 2, the verbal WMC by CMP propensity interaction term approached significance in predicting improvement in layup technique ($B = 0.115$, $p = .076$). Mediator analysis with the Johnson-Neyman technique showed that verbal WMC predicted improvements in layup technique significantly ($p < .05$) if CMP propensity>13. This relation was positive, thus high verbal WMC was positively associated with improvements in layup technique if CMP propensity exceeded 13. Conversely, CMP propensity predicted improvements in layup technique significantly ($p < .05$) if verbal WMC < 16. This relation was negative, meaning that a high CMP propensity was negatively associated with greater improvements in layup technique if verbal WMC was smaller than 16. Nevertheless, inclusion of the interaction terms in step 2 did not lead to a significant prediction model ($R^2 = 0.142$, $p = .163$) or increased model fit ($\Delta R^2 = 0.082$, $p = .109$).

4. Discussion

We examined the effects of explicit and more implicit learning methods on motor learning and self-efficacy in practicing a layup during PE. The main aim was to assess if and how individual differences in verbal WMC and propensity for conscious processing

Table 5
Hierarchical Regression Models with Improvements in Layup Outcome (model 1) and Layup Technique (model 2) as Dependent Variables. Bold values denote $p < .10$.

MODEL 1						
Dependent variable:	**Layup Outcome** (improvements from pre- to posttest)					
	B	β	[95% CI]	p	R^2	ΔR^2
Step 1					0.068 (p = .295)	
Constant	1.791					
Group (E vs. I)	−0.477	−0.091	[−1.748, 0.794]	0.457		
Verbal WMC	0.032	0.045	[−0.142, 0.205]	0.718		
Visuospatial WMC	0.064	0.138	[−0.051, 0.180]	0.269		
CMP Propensity	0.196	0.156	[−0.109, 0.502]	0.203		
Step 2					0.097 (p = .430)	0.029 (p = .550)
Constant	1.884					
Group (E vs. I)	−0.416	−0.079	[−1.699, 0.867]	0.520		
Verbal WMC	−0.064	−0.091	[−0.288, 0.159]	0.567		
Visuospatial WMC	0.057	0.123	[−0.060, 0.175]	0.334		
CMP Propensity	0.272	0.215	[−0.302, 0.847]	0.347		
Verbal WMC by group	0.270	0.235	[−0.114, 0.654]	0.165		
CMP propensity by group	−0.103	−0.069	[−0.773, 0.566]	0.759		
Verbal WMC by CMP propensity	0.020	0.052	[−0.082, 0.122]	0.698		
Step 3					0.097 (p = .543)	0.000 (p = .931)
Constant	1.878					
Group (E vs. I)	−0.407	−0.077	[−1.717, 0.904]	0.538		
Verbal WMC	−0.062	−0.088	[−0.293, 0.169]	0.592		
Visuospatial WMC	0.057	0.123	[−0.062, 0.176]	0.340		
CMP Propensity	0.266	0.211	[−0.328, 0.861]	0.374		
Verbal WMC by group	0.272	0.237	[−0.118, 0.662]	0.168		
CMP propensity by group	−0.098	−0.065	[−0.784, 0.589]	0.777		
Verbal WMC by CMP propensity	0.015	0.038	[−0.143, 0.172]	0.853		
Verbal WMC by CMP propensity by group	0.009	0.018	[−0.196, 0.214]	0.931		

MODEL 2						
Dependent variable:	**Layup Technique** (improvements from pre- to posttest)					
	B	β	[95% CI]	p	R^2	ΔR^2
Step 1					0.060 (p = .361)	
Constant	4.356					
Group (E vs. I)	0.863	0.128	[−0.773, 2.499]	0.297		
Verbal WMC	0.131	0.145	[−0.093, 0.355]	0.246		
Visuospatial WMC	0.059	0.098	[−0.089, 0.207]	0.431		
CMP Propensity	−0.215	−0.133	[−0.609, 0.178]	0.279		
Step 2					0.142 (p = .163)	0.082 (p = .109)
Constant	4.410					
Group (E vs. I)	0.803	0.119	[−0.800, 2.406]	0.321		
Verbal WMC	0.179	0.198	[−0.100, 0.459]	0.205		
Visuospatial WMC	0.039	0.064	[−0.109, 0.186]	0.604		
CMP Propensity	−0.412	−0.254	[−1.130, 0.306]	0.256		
Verbal WMC by group	−0.081	−0.055	[−0.561, 0.399]	0.737		
CMP propensity by group	0.347	0.180	[−0.490, 1.183]	0.411		
Verbal WMC by CMP propensity	0.115	0.234	[−0.012, 0.242]	**0.076**		
Step 3					0.157 (p = .169)	0.015 (p = .279)
Constant	4.322					
Group (E vs. I)	0.946	0.140	[−0.676, 2.569]	0.248		
Verbal WMC	0.213	0.235	[−0.073, 0.499]	0.142		
Visuospatial WMC	0.035	0.059	[−0.112, 0.182]	0.637		
CMP Propensity	−0.503	−0.311	[−1.240, 0.233]	0.177		
Verbal WMC by group	−0.048	−0.033	[−0.531, 0.434]	0.842		
CMP propensity by group	0.433	0.225	[−0.417, 1.284]	0.313		
Verbal WMC by CMP propensity	0.034	0.069	[−0.161, 0.229]	0.730		
Verbal WMC by CMP propensity by group	0.139	0.219	[−0.115, 0.393]	0.279		

influenced the effects of explicit and implicit learning methods. Students significantly improved their layup performance, layup technique, and self-efficacy from pre- to posttest, irrespective of the learning method (explicit vs. implicit group) that was used to guide them during practice. Different from expectations, individual differences in verbal WMC and CMP propensity did not distinguish the extent to which either explicit or implicit learning methods were effective for motor learning.

The included manipulation check revealed that the explicit learning group displayed higher conscious control during posttest compared to the implicit learning group. Specifically, they focused significantly more on the way they placed their feet and the way they jumped during layup performance. As such, the experimental intervention seemed to have been successful at inducing a relatively explicit learning process in the explicit group – at least significantly more so compared to the implicit group. Even so, in this PE setting both explicit and implicit learning methods seemed to have been similarly successful at improving movement skill and self-efficacy. This is in line with the findings of Kok et al. (2021) and also with the review of Van Abswoude et al. (2021) who concluded that both implicit and explicit methods are similarly effective and practitioners can use both methods. At a group level, the positive effects of implicit learning (as opposed to explicit learning) for children seem trivial and much smaller than originally anticipated (for example by Masters et al., 2013).

A distinct finding was that individual differences in verbal WMC and CMP propensity did not influence which learning method (explicit or implicit) was most effective for motor learning. We designed experimental conditions that were representative for PE by cocreating explicit and implicit learning methods with PE teachers in line with their educational practice. While we did succeed in creating significant contrast between explicit and implicit interventions, this may still have been smaller compared to previous laboratory studies (e.g., Buszard et al., 2017; Tse & van Ginneken, 2017) or other studies in PE (Kok et al., 2021; Van Duijn et al., 2019). Although the explicit and implicit interventions of the present study did demonstrably consist of generally accepted explicit and implicit learning methods (Kleynen et al., 2014), instructions of the implicit intervention still exhibited quite a number of movement rules (i.e., 4–6, even though formulated as analogies or as external focus instructions), and the explicit intervention contained a little touch of external focus instructions (even though far less than the implicit condition). In Van Duijn et al. (2019) for example, the contrast between the explicit condition (i.e., six explicit internal focus instructions) and implicit condition (i.e., one analogy) was probably larger. Furthermore, learning methods may have a smaller influence on motor learning in groups (e.g., the present study) compared to learning in small groups (e.g., Kok et al., 2021; Van Duijn et al., 2019) or learning in individual (e.g., laboratory) settings. In the present study, for example, the teacher-student ratio was low compared to Kok et al. (2021) and Van Duijn et al. (2019) with the teacher guiding 20–25 students simultaneously instead of 2–4 students or 6–10 students, respectively. According to Van der Kamp et al. (2015), a group setting leads to different interactions compared to a laboratory setting, which may influence the motor learning process. Accordingly in our study, the teacher likely had less direct control over the learning process compared to a small group or individual laboratory setting, which may have resulted in less feedback provided per student and more interaction between peers. This may have contributed to smaller experimental contrast between the intervention groups than typically reported. Consequently, the difference on the explicit-implicit learning continuum between the interventions may have been too small for the individual constraints to play a pivotal role. Measures of self-reported use of declarative knowledge seem to support this interpretation: although we found differences between groups, these were small and did not cover the total number of applied movement rules nor every aspect of movement execution. The small difference on explicit-implicit learning continuum may originate from the dynamics in and characteristics of general PE. Therefore, the observed (lack of) effects may be representative for general PE.

Besides influence of task constraints (i.e., teacher-student ratio, operationalization of explicit and implicit conditions aligned with educational practice), the absence of the distinctive character of individual constraints for explicit and implicit learning may also be explained by the relative strain of the interventions on verbal WMC. Verbal WMC increases with age (Huizinga et al., 2006) and is associated with overall learning (Alloway, 2009; Gathercole, Pickering, Knight, & Stegmann, 2004). The students in the present study followed secondary education on a fairly high level and demonstrated high scaled verbal working memory capacity (i.e., $M_{\text{scaled score listening recall}} = 120 \pm 13.8$). In contrast, students in Kok et al. (2021) exhibited special educational needs that were associated with lower WMC capacity (e.g., Dahmen, Putz, Herpertz-Dahlmann, & Konrad, 2012; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Van der Molen, Van Luit, Jongmans, & Van der Molen, 2009; Wang et al., 2017) and showed low scaled verbal WMC scores. Furthermore, age could have played a role, since the participants in the present study were a bit older compared to Kok et al. (2021, with participants approx. 1 year younger) and Buszard et al. (2017, with participants approx. 3 years younger). Overall, verbal WMC of the students in the present study may have been high enough to profit from the explicit (but also implicit) learning condition. The fact that the explicit group unexpectedly (and unfortunately) demonstrated higher verbal WMC than the implicit group may have contributed further to this notion. Together, these findings may suggest that verbal WMC only predicts learning in situations in which a multitude of explicit instructions have to be processed, children exhibit smaller verbal working memory capacity, are relatively young, and teachers/experimenters have tighter control over task constraints (as in Buszard et al., 2017; Kok et al., 2021). If so, verbal WMC may not be a critical individual constraint to take in account in choosing learning methods in general PE settings.

We did not find evidence for the hypothesized three-way interaction between learning method, verbal WMC and propensity for conscious processing in explaining learning outcomes. However, there were weak indications that a high propensity for conscious control enhanced learning the layup technique if students also exhibited relatively large verbal WMC – and conversely, that for students with a relatively small verbal WMC, a high propensity for conscious control diminished learning the layup technique. This would be in line with our hypotheses, as we expected that students could only profit from (a propensity for) conscious processing if they had the capacity to do so (i.e., high verbal WMC). However, care should be taken with interpreting these results as this finding was not significant ($p = .076$). Therefore, the relationship between CMP and verbal WMC in explaining motor learning needs further study.

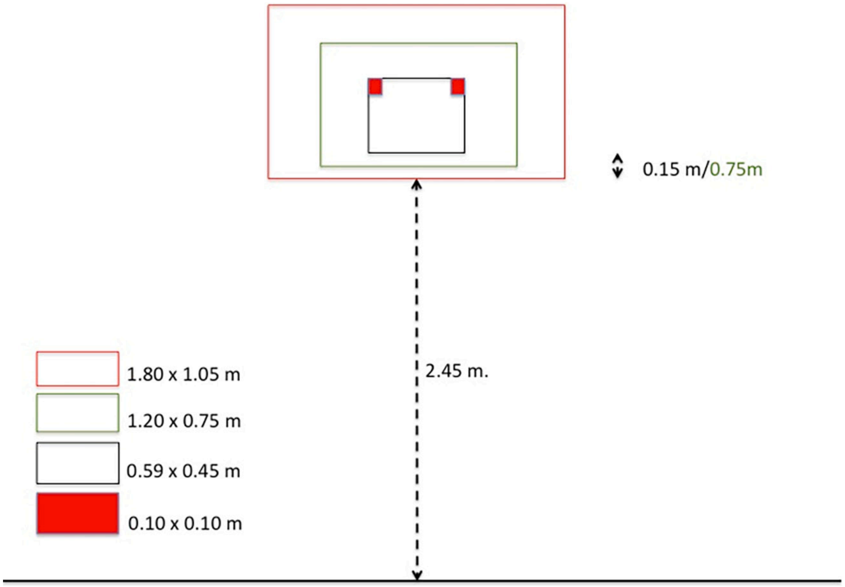
In the present study, both the explicit and implicit interventions were designed to optimally serve learning the layup in a PE setting. It turned out that in the examined setting, both roads led to Rome, that is, they led to significant motor learning and increased self-efficacy, irrespective of measured individual differences in verbal WMC and CMP propensity. Further study is needed to examine under which conditions (e.g., number of rules in intervention, verbal WMC, teacher-student ratio) individual constraints such as verbal WMC and propensity for conscious processing influence the effects of explicit and implicit learning. Furthermore, the precise interaction between verbal WMC and propensity for conscious control needs further study.

CRediT authorship contribution statement

Marjan Kok: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Project administration. **Jennifer Nuij:** Methodology, Investigation, Project administration. **Elmar Kal:** Conceptualization, Methodology, Formal analysis, Writing – review & editing. **John van der Kamp:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Appendix A. Overview of the applied explicit and implicit learning methods per group per practice session

Practice Session 1: Footwork and positioning towards the basket

Explicit Group	*Implicit Group*
Layup situation:	*Layup situation:*
• similar to pre- and posttest situation	• Instead of at the cone, students started from a platform (27 cm. height) • A red and yellow circle were placed to mark foot positions. • Instead of a basket, students had to score in rectangles of different sizes that were visualized at the gym hall wall: 
Instructions (for right-handed students):	*Instructions (for right-handed students):*
• *'Start at the cone'* • *'Perform two steps towards the basket: right foot-left foot'* • *'Jump from the left foot'* • *'Make sure that you position yourself close to the basket, but not that close that you end up throwing from a position under the basket.'*	• *'Start at the platform'* • *'Perform a step-step-jump with your:* • ***Rr**right foot on the **Rr**red circle* • ***Ll**left foot on the ye**LL**ow circle'* And • *'Try to hit the big rectangle with the ball, if you hit the rectangle twice in succession, you try a smaller one, if you miss, you try a bigger one'.*
Incidental guidance during practice: The teacher:	*Incidental guidance during practice:* The teacher:
• Provided motivational feedback (e.g., *'you're doing fine'* or *'good score'*) • Reminded individual students of an instruction if the teacher noticed that an instruction was not followed (e.g., *'try to perform the first step with your right foot'*) and instructed to *'read the instructions on footwork again and take a look on the video how*	• Provided motivational feedback (e.g., *'you're doing fine'* or *'good score'*) • Reminded individual students of an instruction if the teacher noticed that an instruction was not followed (e.g., *'try to put your **Rr**right leg on the **Rr**red circle'*) • tried to evoke a fluent and fast movement sequence by accompanying the movement with a paced verbal '*and-step-step-throw*' if a student did well.

(*continued on next page*)

(*continued*)

Explicit Group	*Implicit Group*
the girl on the video performs her footwork'. • Instructed a students who did well with*: 'try to make fluent and faster movements'*.	

Practice Session 2: Jump and throw

Explicit Group	*Implicit Group*
Layup situation: • similar to pre- and posttest situation	*Layup situation:* • similar to pre- and posttest situation, with the exception that a red and yellow circle were placed to mark foot positions.
New instructions (for right-handed students): • *'Jump from your left leg'* • *'Your right knee goes up simultaneously with your right hand'* • *'Throw the ball with one hand* via *the backboard in the basket'* • *'Guide the ball as long as possible and release the ball on the highest point'*	*New instruction (for right-handed students):* • *'Pretend as if you are a jumping jack toy on the side of the ball'* (the teacher shows an actual jumping Jack toy and emulates the movement of the jumping jack toy himself)
Incidental guidance during practice: The teacher: • Provided motivational feedback (e.g., *'you're doing fine'* or *'good score'*) • Reminded individual students of an instruction if the teacher noticed that an instruction was not followed (e.g., *'try to put your knee more up'* or an instruction from practice session 1) and instructed to *'read the instructions on the footwork/jump/throw again and take a look on the video how the girl on the video performs her footwork/jump/throw'*. If the student was doing well: • the teacher instructed *'try to make a fluent and faster movements'* or • the teacher instructed *'try to jump higher'*	*Incidental guidance during practice:* The teacher: • Provided motivational feedback (e.g., *'you're doing fine'* or *'good score'*) • Reminded individual students of an instruction if the teacher noticed that an instruction was not followed (e.g., *'pretend to be the jumping Jack toy'* or an instruction from practice session 1) If a student was doing well: • the teacher removed the red and yellow circle or • the teacher tried to evoke a fluent and fast movement sequence by accompanying the movement with a paced verbal '*and-step-step-throw' or* • the teacher instructed *'push the ground powerful away'* or • the teacher instructed *'try to reach the jumping Jack arm as close as to the basket as possible'*

Practice Session 3: Pointing on the backboard

Explicit Group	*Implicit Group*
Layup situation: • similar to pre- and posttest situation	*Layup situation:* • similar to pre- and posttest situation, with the exception that a red and yellow circle were placed to mark foot positions.
New Instructions (for right-handed students): • *'Try to point the ball at the right upper corner of the black rectangle on the backboard'*	*New Instructions (for right-handed students):* • *'Pretend as if the ball is a stamp and the black rectangle is an envelope: Put the stamp on the envelope'*
Incidental guidance during practice: The teacher: • Provided motivational feedback (e.g., *'you're doing fine'* or *'good score'*) • Reminded individual students of an instruction if the teacher noticed that an instruction is was not followed (e.g., *'Did you try to point on the right upper corner of the black rectangle?'*) and instructed if the an instruction from practice session 1 or 2 was not followed: *'read the instructions on the footwork/jump/throw again and take a look on the video how the girl on the video performs her footwork/jump/throw'*. If the student was doing well: • the teacher instructed *'try to make a fluent and faster movements'* or • the teacher instructed *'try to jump higher'*	*Incidental guidance during practice:* The teacher: • Provided motivational feedback (e.g., *'you're doing fine'* or *'good score'*) • Reminded individual students of an instruction if the teacher noticed that an instruction was not followed (e.g., *'Did you try to put the stamp on'?* or an instruction from practice session 1 or 2) If a student was doing well: • the teacher removed the red and yellow circle *or* • the teacher tried to evoke a fluent and fast movement sequence by accompanying the movement with a paced verbal '*and-step-step-throw'* or • the teacher instructed *'push the ground powerful away'* or • the teacher instructed *'try to reach the jumping Jack arm as close as to the basket as possible'*

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