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Original Article

Self-regulated learning strategies during self-controlled practice in physical education

JOOP DUIVENVOORDEN[1], JOHN VAN DER KAMP[1,2], IVO VAN HILVOORDE[1,2], GEERT SAVELSBERGH[2]
[1,2,,3] Windesheim University of Applied Sciences, Human Movement and Education Research Centre, Zwolle, The NETHERLANDS
[2,3,4] Vrije Universiteit Amsterdam, Faculty of Behavioural and Movement Sciences, Amsterdam, The NETHERLANDS

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Abstract
Introduction: Self-regulated learning entails students to be able to organize or control their practice to actively control the acquisition of skills. In this respect, Zimmerman (2002) discerns three cyclical phases: a forethought phase for planning, a performance phase for executing and self-observation and a self-reflection phase to evaluate practice. The implication is that individual differences in students' self-regulated learning should lead to observable differences in practice behaviors. This study aims to uncover such differences in self-controlled practice behaviors of physical education students, with a special focus on the forethought (i.e., strategic planning) and the performance (i.e., self-observation) phases.In addition, this study evaluates whether such differences are related to self-efficacy, task motivation and predicted task success score**. Methods**: A total of 79 students (*M*age = 13.1 years) practiced a novel aiming task in which they self-controlled the distance from which they practiced. We determined students' practice strategies and gauged self-reported (i.e., self-efficacy and task motivation) and behavioral(i.e., predicted task success score) self-regulated learning indices. **Results**: Pearson correlations revealed three groups based on their practice strategy: A Distance-group (i.e., adjusted distance based on foregoing distance), a Score-group (i.e., adjusted distance based on foregoing performance), and an Other-group (i.e., no strategy was discerned). No group differences in self-regulated learning indices were observed, except for the predicted success score. The Distance-group underestimated practice performance whereas the Score and Other-groups overestimated performance. **Discussion:** This study identified different observable behaviors that indicate distinct ways in which students apply self-regulated learning during self-controlled practice. These differences relate to the degree in which they used strategies and monitored their performance and underline that students' ability to self-regulate can be observed directly during practice.
Keywords: task analysis, strategic planning, self-monitoring, practice behavior, constraints-led approach.

Introduction

Self-regulated learning is pertinent forstudents' development. Being able toplan, monitor and evaluate practice allowsstudents to actively control theacquisition and advancement of skills (Zimmerman, 2002). Students capable of self-regulated learning autonomously monitor and adapt practice strategies in order to effectively pursue personal goals (Zimmerman, 2000; 2002; 2006), allowing them to practicewithout continuous supervision of a teacher (Byra, 2006). Additionally, self-regulated learners are more prone to continue learning, even when this is no longer organized for them (Zimmerman, 2002, Girard et al., 2019).Forphysical education (PE), a crucial aimis to promote life-long participation in movement activities, and the encouragementof students'self-regulated learningcan be an important meansto this end.

Self-regulated learners autonomously engage in aforethought phase, a performance phase and a self-reflection phasein which thoughts, feelings and actions support the attainment of personal goals (Goudas et al., 2013; Zimmerman, 2000). During the forethought phase, these learnersanalyze the task and regulateself-motivational beliefs. Task analysis includes goal setting and strategic planningof subsequent practice in order to achieve intended goals. PE-students engaged in forethought task analysis can, for instance, choose to match taskdifficulty to their (perceived) abilityor to focus on improving movement technique.Self-motivational beliefs (i.e. self-efficacy, outcome expectations and intrinsic interest)are important prerequisites for students to engage in proactive goal settingand to put effort in their accomplishment(Chase, 2001; Chatzipanteli et al., 2015; Cleary &Zimmerman, 2001; Roure et al., 2019; Ulstad et al., 2016).

In the subsequent performance phase PE-students do actually practice, that is, they apply the planned strategy and perform the motor task. In effective self-regulation, thispractice is guided byself-control and self-observation. Self-control processes, such asself-instruction and the deliberate application ofthe intended practice

Corresponding Author: JOOP DUIVENVOORDEN, E-mail: j.duivenvoorden@windesheim.nl

strategy,serve to increase task focus and to reach the goals set in the forethought phase (Anderson, 1997; Goudas et al., 2013; Zimmerman&Moylan, 2009). The process of self-observation or monitoringfacilitates learners' awareness of performance and progression towards theirgoals.

The final phase of the self-regulated learning cycle is the self-reflection phase. This phase follows performance and consists of self-judgement and self-reaction. Effective self-regulated learners use self-judgement to evaluate planningand performance and make attributions with respect to success and failure, affecting subsequent forethought processes.Finally, self-reactions, which can be bothcognitive and affective, affect decisions concerning the practice strategy and the willingness to engage in future self-regulated learning cycles. (Zimmerman &Moylan, 2009).

Accordingly, effective self-regulated learning is aided bythe acquisitionand application of self-regulated learning processessuch asgoal setting, strategic planningof practice and monitoring performance(Anderson, 1997; Jonker et al., 2011; Pitsi et al., 2015; Zimmerman& Martinez-Pons, 1986).A considerable amount of research confirmed the positive relation between the application self-regulated learning processes and learning a skill in PE. Ommundsen (2006), for example, used questionnaires to assess indices for effective self-regulated learning. This author reported that 15- and 16-year-old PE-students who held task-oriented goals (rather than performance-oriented goals) more often reported to use self-regulation processes as described in Zimmerman's three phase model. More specifically, task orientation promoted persistent effort to work towards proximal and more distant goals and it enhanced the monitoring of progression and (re)organization of these goals.Further to this point, Andrieux et al. (2016) showed that self-control over task difficulty in a computer interception task, especially in early practice, resulted in lower errors 24 hours after practice.In actual PE lessons, Kolovelonis et al. (2012) stimulated the use of self-regulated learning processes while 11- and 12-year-old students practiced dribbling a basketball. The children wereinstructed to either use a (presumably) effective or a less effective self-regulated learning protocol. The purported effective protocol was derived from the social cognitive training model for self-regulated learning, which describes training as proceeding from observation and emulation (i.e., both social in nature) to self-control and self-regulation (i.e., both self-oriented) (Kolovelonis, Goudas & Gerodimos, 2011; Zimmerman, 2000; 2013). The protocol included positive feedback and performance reminders within the first minutes of practice for correctly emulating the dribble skill, while later in the practice session the use of goal setting and a self-recording scale were included. By contrast, the three other groups performed the same practice drills, but without the self-regulated learning instructions in one or both parts of the practice session. Kolovelonis et al. (2012) reported that the effective protocol resulted in the largest progression in dribbling speed. Although self-regulated learning was not genuinely self-controlled, as in fact the protocol was imposed on the PE-students, the study shows that stimulationof self-regulated learning processes improves motor skillperformance from pre-test to post-test.

Importantly, most research examiningself-regulated learning and its benefitsusedquestionnaires,such as theMotivated Strategies for Learning Questionnaire (MSLQ,Pintrich et al., 1993)or interviews (e.g. SRLIS,Zimmerman &Martinez-Pons, 1988), to gauge the extent to whichstudents apply self-regulated learning processes. Apossible drawback ofthese self-report measures is that they heavily dependon students' reflective skills, which may or may not be sufficiently advanced (Cleary et al.,2012; Jonker et al., 2011; Kermarrec et al., 2004; Zimmerman, 2008).To further this point, the constraints-led approach (e.g., Chow et al., 2016; Renshaw &Chow, 2019; Moy et al., 2020) explains(motor) behavior as emerging from individual, task and environmental constraints that momentarily define individual functional answers to encountered movement challenges.This theory – andmore generally, an ecological perspective–argues that reflective, retrospective thoughts on a previoussituation, as assessed in questionnaires, donot necessarilyaccurately represent actual behaviors in that context (Van Andel et al., 2017).Hence, it is therefore vital to also directly examine students' actual behaviorsin situations that evoke self-regulated practice(Boekaerts &Corno, 2005;Toering et al., 2011; Zimmerman, 2008).Kermarrec et al. (2004) identifiedself-regulated learning processesas they spontaneouslyemerged in a PE-lesson where students practiceda new volleyball, badminton, gymnastics or table tennis skill. They reported a total of 17 self-regulated learning behaviors, which could be divided into behaviors that facilitate the acquisition of skill (e.g., to listen to instructions or to focus attention),supportbehaviors(e.g., to manage motivation and the task), and metacognitive strategies that, for example, enable self-testing and self-evaluation.The study by Kermarrec et al. (2004) is one of few studies that used overt behaviors during self-controlled practice as an indicator for self-regulated learning. The current study further explores the observation of self-controlled practice behavior as a way to gaugeself-regulated learningstrategies in PE. It therefore uncovers differences in planning and monitoring strategies while PE-studentsautonomously adjust task difficulty in a novel aiming task.

According to Zimmerman's (2000) self-regulated learning model, effective self-regulated learning includes task analysis (i.e., goal setting and strategic planning) and self-observation (i.e., self-monitoring), and if appropriate, adjustments in task analysis. In settings that involve supervised skill acquisition, such as PE, these self-regulated learning processes can be deduced by directly observing the behaviors during the performance phase of self-controlled practice.Hence, the aim of the current descriptive study is to determine whether differences in the way students organize task difficulty during practice, inform about the application of task analysis(i.e., strategic planning) and/or self-observation (self-monitoring). It further aims to assess how the discerned distinctions in practice behavior relate to self-reported indices of self-regulated learning (i.e., motivational beliefs and the accuracy of the predicted score during self-controlled practice). To this end, self-controlled practice behavior was determined within a group of 12- to 14-year-old children who practiced a new aiming task in a PE-lesson.

Material & methods

Participants

Students from four higher secondary and pre-university educationclasses in the Netherlands participated in the study. From a total of 108 students, 79 (*M* age = 13.1 years; *SD* = 0.44 years, 48% girls) gave consent and participated on both days of the experiment.All children were novel to the task they practiced during the study. The localScientific and Ethical Review Board had approved the study. Written consent was obtained from parents and children prior to the study.

Equipment and Material

The study was conducted in an indoor PE-facility and involved an aiming task for which the students had to hit a red-coated foam ball (ø = 0.09 m) with a hand paddle (©Nijha) into a target area (1.20 m × 0.80 m) on the floor via a rebound on the wall using a forehand stroke (Figure 1). The target area was positioned 1.00 meter from the wall. Thenearest aiming distance (marking 1) was 1.20 meters in front of the target area. Subsequent markers were 0.75 m (i.e., marking 1 to 5) and 0.40m (i.e., marking5 to 8) apart. A digital wide-angle camcorder (Panasonic, HC-V770)placed on a tripod in a corner of the facility, recorded the entire session.

Measures

A *self-efficacy* scalewas used to gauge participants' belief to perform successfully. Following Kolovelonis et al. (2010), an adjusted version of Bandura's self-efficacy scale for children was used. Accordingly, for each marking, the participants answered the question: "How sure are you that you can hit the target area in 3 out of 5 attempts from this distance?" Participants responded by inserting a vertical mark on a standard scale ranging from 0 to 100 with 10-point intervals. Descriptors were placed below the values 10 ("not sure"), 40 ("somewhat sure"), 70 ("pretty sure") and 100 ("entirely sure").

Task motivation was measured using two questions on a similar scale ranging between 0 and 100 with 10-point intervals. The first question was: "How important is it to you that you successfully perform this activity?" Following Chase (2001), descriptors were placed below the values 10 ("not important"), 40 ("somewhat important"), 70 ("pretty important") and 100 ("very important"). The second question was "How much do you like practicing this task?" Following Kolovelonis et al. (2012), descriptors were placed below the values 0 ("not at all"), 20 ("a little bit"), 40 ("a bit"), 60 ("pretty much"), 80 ("a lot") and 100 ("very much").

During practice, participants worked in couples, one of whom kept a printed practice log for the other. This log held a pre-printed format for 20 practice blocks to record *practice distance* (i.e., the marking at which the classmate practiced), his or her *predicted score* and *actual score* at that marking (see *Procedure* below).

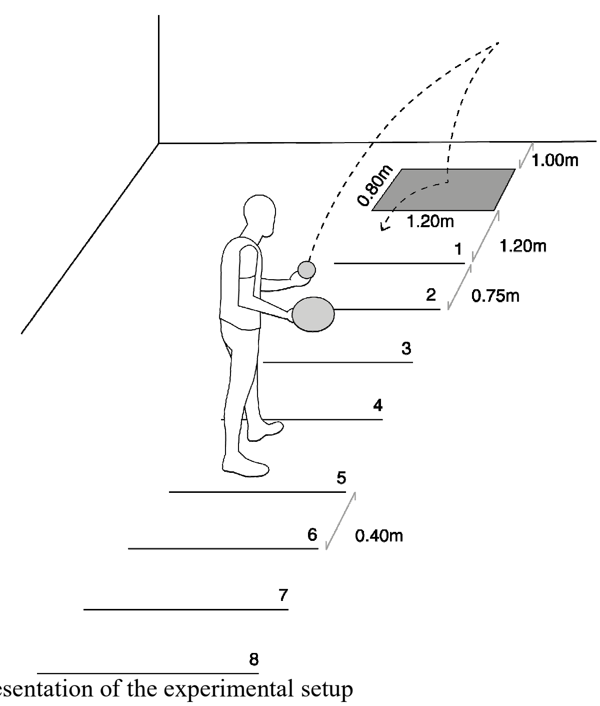

Figure 1: Schematic representation of the experimental setup

Design

The experiment consisted of two sessions conducted at separate days over a maximum period of seven days. Session 1consisted of instructions about the experiment and the aiming task, followed by a 3-minute familiarization period and the assessment of initial ability for the aiming task.During Session 2, the self-efficacy and motivation scales were administered before the students were allowed 10 minutes of self-controlled practice of the aiming task.Both sessions were video-recorded for off-line analysesand correction of practice logswhen these contained missing or unclear data.

Procedure

Instruction and initial ability

At the beginning of Session 1, participants were instructed about the experiment, the rules for the taskand how to execute aforehand strokeusing the hand paddle.The experimenterinstructed the participants that the ball had to bounce from the wall into the target area (see Figure 1). He further explained to hit the ball from below or sideways with a forehand stroke, allowing the ball to make an upward curve towards the wall. Participants were also told to direct the foot contralateral to the hand holding the bat towards the target area. Then, the experimenter demonstrated these crucial technical aspects of the forehand stroke and the task. During the subsequent 3-minute familiarizationperiod, the target area was replaced by a small cross-shaped marking and distance markings were not present. When appropriate, the experimenter gave technique reminders and encouraged the participants to aim at the cross-shaped marking.Following familiarization,participants performed a series of trials to determine theirinitial ability. For these trials, the target area and distance markings were present. In order for task-difficultyto match perceived competence, participants started at the maximum distance from whichthey thought they could hit the target area in three out of five attempts. When at least three out of five attempts were successful,the participant moved backward to the next distance marking, otherwise the participant moved forward to a closer distance marking. This procedure was repeated until the participant failed to score three out of five attempts (i.e., for distances greater than their perceived maximum achievable distance) or succeeded to do so (i.e., for distances shorter than their perceived maximum achievable distance).The largest distance at which the children were successful, was recorded as their initial ability.

Self-controlled practice

The secondsessiontook place within a week of the first session.A maximum of 6 participants (i.e., 3 couples)practiced at the same time on three separate tracks, which were at least 4.00 m apart.Before the self-controlled practicesession, participants completed the self-efficacy and task motivation scales. Next, the experimenterverbally instructed and demonstrated the crucial technical aspects of the forehand stroke once more. Participants were told to use the forehand stroke at every distance marking. Theywere also informed that the purpose of this lessonwas to improve their aiming skills as much as they could, that is, to maximize the distance from which they successfully managed to let the ball rebound intothe target area in at least three out of five attempts.For this study a performance (i.e., outcome) goal as applied by Kolovelonis, Goudas &Dermitzaki(2011) was chosen in order tostimulate an external focusthat is congruent with the purpose of the lesson.

During the 10 minutes of practice, the participants self-controlled the marking (i.e., distance) from which they practiced. They were allowed to change the distance at own choice, but only after having finished a block of five attempts.Before each block of five attempts, participants predicted the amount of trialsthey thought would successfully hit the target area.The practice distance, thepredicted score, and the actual score were recordedin the practice log by the participant’s classmate (and later verified from the video-recordings by the experimenter). When considered appropriate, the test leader gave technique reminders during practice, and encouraged the participants to aim at the center of the target area.He did not provide any instructions or feedback regarding practice distances. After the first 10 minutes of self-controlled practice, the participants changed roles.

Data Analysis

Categorization of Participants in Groups

First, each participant was classified in one of three groups based on the observed self-controlled practice behavior. The categorization was made accordingto the pattern of change in the distances(i.e., organization of task difficulty during practice) from which participants chose to practice over the first eight blocks.[1]Initial perusal of the data guided by Zimmerman’s social cognitive model of self-regulated learning suggested three patterns of change: 1) participants whoincreasedpractice distance systematically after each block, regardless of the score (i.e., successful rebounds) in theforgoing block, 2)participants who changedpractice distance dependent on their scorein the foregoing block, and 3)the remaining participants whoseemingly followed anunidentified or

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[1] Note that the number of practice blocks that participants underwent was not fixed. The mean number of blocks participants practiced was 10.0, and ranged between 6 and 15. For the seven participants who did not complete eight blocks, categorization was based upon six (n=5) or seven (n=2) blocks. A 9th block was practiced by 56 participants. The number of participants completing 10 and more blocks was substantially less.

no pattern. For each individual participant, it was determined which of the three patterns of change they most closely adhered to. To this end, for each participant Pearson correlation coefficients were calculatedacross the first eight practice blocksto determine:1) the correlation between distance in the current practice block (D) and the distance in the foregoingpractice block (D-1), and 2) the relation between ΔD (i.e., the increase or decrease in distance between current (D) and foregoing (D-1) practice block) and the actual score in the foregoing block (S-1).If the current practice distance (D) was best predicted by the foregoing distance (D-1), the participants regulatedor pre-planned distance according to a strategy that is based on prior distance, irrespective of their performance score. If increase or decrease in practice distance (ΔD) is based on the score in the foregoing practice block (S-1), participants regulated distance according to a strategy based on prior distance *and* the monitoringof performance. Participants were assigned to the Distance-groupif the strongest of the two calculated correlationswas between D and D-1 with $r \geq .5$, while participants who showed the strongest correlation between ΔD and S-1 with $r \geq .5$ were assigned to the Score-group. The remaining participants, who seemingly used no strategy or analternative strategy that we were unable to identify,were assigned to the Other-group. For each group, mean age and mean initial ability were calculated.

Self-Regulated LearningVariables

Questionnaires were used to gauge self-reported self-efficacy and task motivation (i.e., task importance and enjoyment). For self-efficacy, the average of the eight pre-practice0 to 100-point self-efficacy ratingswas calculated (Cronbach's alpha = .90), while task importance and enjoyment were both taken from a single 0 to 100-point rating. Actual score during the self-controlled practice session was signified by the eight actual scores corresponding to the first eight blocks the student completed. Finally, asbehavioral indicators for self-regulated learning, two aspects of accuracy of the predicted score during the self-controlled practice sessionwere determined by calculating *prediction bias* ($PB = \frac{\sum(Ps_i - As_i)}{n}$) and *prediction variability* ($PV = \frac{\sum|Ps_i - As_i|}{n}$) over the first eight blocks for each participant. In these equations $Ps_i$and As_irespectively are the predicted and actual score for the i^{th}block. n is the amount of blocks(i.e., 8 for most participants). Prediction bias signifies the mean difference between predicted and actual score. It represents the direction of estimation errors. A negative value for PB represents an underestimation of the actual scores during self-regulated practice, whereas a positive score represents overestimation. Prediction variability is the mean absolute difference between predicted and actual score. Prediction variability represents the magnitude of estimation errors, irrespective of whether the difference reflects an over- or underestimation.

Statistical Analyses

For comparisons between the three groups,age,initial abilityandthe dependent measureswere submitted to separate one-way analyses of variance. Post hoc analyses were performed using Tukey's HSD test. Effect size was calculated through η^2. In addition, for practice distance and actualscore during self-controlled practice, a 3 (group: Distance-group, Score-group, Other-group) × 8 (practice block1-8) analysis of variance with repeated measures on the last factor was conducted. For these tests, Greenhouse-Geisser correction was used when the assumption of sphericity was violated,effect sizeswere calculated by η_p^2 andpost hoc analyses were performed using Tukey's HSD test.

Results

Assigningparticipantsto strategy groups.

Each participant was first assigned to one of three groups based on their individual pattern of change in practice distances (see Table 1). The Distance-group (n = 24) regulated their practice by systematically changing practice distance based on the foregoing distance. The Score-group (n = 29) regulated changes in practice distance based on the score in the foregoing practice block. The participants in the Other-group (n =26) either showed no pattern of change in practice distances or a pattern that we were unable to identify. An analysis of variance revealed no significant differences for age between the three groups, $F(2,78) = .69$, $p = .51$, $\eta^2 = .02$. Analyses of variancealso did not indicate a significant group difference for initial ability, $F(2, 78) = 2.13$, $p = .13$, $\eta^2 = .05$.There were obvious significant main effects for group on the correlations between foregoing distance (D) and current practice distance (D-1), $F(2,78) = 40.75$, $p < .001$, $\eta^2 = .52$, and change in practice distance (ΔD) and foregoing score (S-1), $F(2,78) = 75.12$, $p < .001$, $\eta^2 = .67$.Post hoc analyses confirmed that the Distance-groupshowedsignificantly stronger correlation than the Score- and Other-group for the former relationship, while the Score-group had significantly stronger correlation than the Distance- and Other-group for the latter relationship.

Table 1

Characteristics of the Distance-, Score- and Other-group. Values between brackets are standard errors.

Group	r (D-1,D)	r (S-1, ΔD)	N (f/m)	Age	Initial ability
Distance-group	.85 (0.05)	.07 (0.03)	24 (12/12)	13.17 (0.08)	2.96 (0.27)
Score-group	.03 (0.08)	.66 (0.02)	29 (16/13)	13.06 (0.08)	2.10 (0.24)
Other-group	-.01 (0.08)	.17 (0.05)	26 (10/16)	13.04 (0.09)	2.65 (0.38)

Self-regulated learning variables

Practicedistance

Figure 2 shows the mean distances that each of the groups practiced from during subsequent blocks of the self-controlled practice session. Repeated measures analysis of variance showed a main effect for blockfor practice distance, $F(5.315, 366.701) = 29.40$, $p < 0.001$, $\eta_p^2 = .30$. Post hoc tests indicated that from block 3to 8practice distance was significantly greater than in block 1. After block 4, no further significant increases in distance occurred. Moreover, a significant group × block interaction was found, $F(10.692,366.701) = 7.19$, $p < .000$, $\eta_p^2 = .17$. Post hoc tests indicated a significant increase in distance within the Distance-group over both the first and second half of the blocks. For the Score- and Other-group,no significant distance changes across blocks were found. Furthermore, the Distance-group practiced at larger distances compared tothe Score- andOther-group during block 7 and compared to the Other-group during block 8. No further meaningful significant differences were found. No main effect for group was found, $F(2,69) = 1.89$, $p = .16$, $\eta_p^2 = .05$.

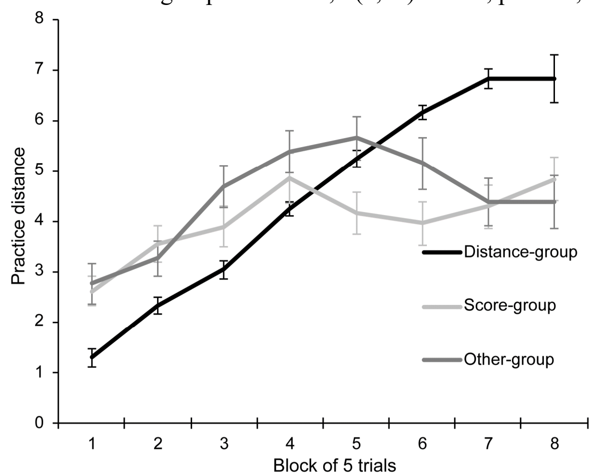

Figure 2. Mean practice distance per group for each block of 5 trials. Error bars indicate standard errors.

Actual score

Figure 3 shows the mean actual scores for each group during the self-controlled practice session. Repeated measures analysis of variance showed a main effect for block for actual score, $F(7,483) = 4.24$, $p < .001$, $\eta_p^2 = .06$. Post hoc testsindicated that actual scores for block 1 were significantly higher than scores for blocks 4,5,6 and 8. There was no main effect for group, $F(2, 69) = 1.16$, $p = .32$, $\eta_p^2 = .03$, but a group × block interaction was discerned,$F(14,483) = 2.42$, $p = 0.003$, $\eta_p^2 = .07$. Post hoc testsindicated that the Distance-groupsignificantly outperformed the Score-group in block 2. Moreover, the Distance group scored significantly higher in block 1 compared to block6 and 8, and in block 2 compared to block 5, 6 and 8, while the other groups did not show any differences between blocks. No other meaningful significant differences were found.

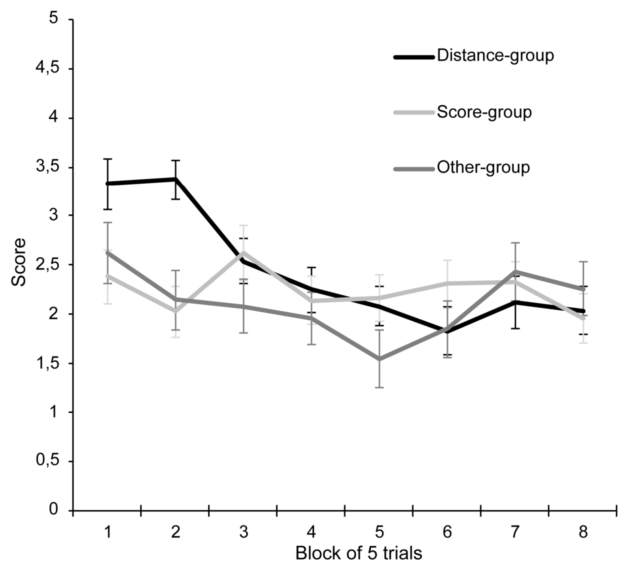

Figure 3. Mean practice scores (number of successful attempts out of five trials per block) per group. Error bars indicate standard errors.

Self-motivational beliefs

Means and standard errors for the self-motivational beliefs are presented in Table 2. Analysis of variance revealed no significant differences between groups for self-reported self-efficacy, $F(2,78) = 1.76$, $p =.18$, $\eta^2 = .04$, task importance $F(2,76) = 0.68$, $p = .51$, $\eta^2= .02$, and enjoyment,$F(2,76) = 1.51$, $p = .23$, $\eta^2= .04$.

Table 2

Means and standard errors for self-motivational beliefs and behavioral indicators for self-regulated learning.

Group	Self-efficacy	Importance	Enjoyment	Prediction bias	Prediction variability
Distance-group	45.19 (3.13)	56.43 (5.43)	71.22 (4.42)	-0.36 (0.14)	0.96 (0.09)
Score-group	40.38 (2.80)	48.45 (4.74)	62.24 (3.83)	0.17 (0.12)	1.04 (0.05)
Other-group	48.96 (3.97)	53.72 (4.83)	70.60 (4.36)	0.32 (0.12)	1.11 (0.08)

Behavioral indicators for self-regulated learning

During the self-controlled practicesession, prediction bias showed a significant main effect for group, $F(2,78) = 7.94$, $p =.001$, $\eta^2 = .17$. Post hoc analysis indicated that the negative mean prediction bias (i.e.,underestimation of the actual score) displayed by the Distance-groupdiffered significantlyfromthe positive mean prediction biases (i.e., overestimation) of the Score-group and Other-group (see Table 2). Analysis of variance revealed no significant differences between groups for prediction variability, $F(2,78) = 0.98$, $p = .38$, $\eta^2 = 0.03$.

Discussion

The social cognitive model of self-regulated learning (Zimmerman, 2000) describes effective self-regulated learning as a process of cyclical progression through forethought, performance and self-reflection phases. Students that successfully self-regulate are able to adopt a practice strategy that leads them to effectively achieve their learning aims. Typically, questionnaires have been used to assess competence across the different processes that constitute the phases of self-regulated learning. In PEhowever, practice strategies result in overt behavior that allowsobservation of self-regulated learning behaviors, particularlyduring the performance phase. This leads to the unique opportunity to evaluateself-regulation strategies while students engage in practice activities.Therefore, thefirst aim of this study was to identify the variances in self-regulated practice behavior, where we especially focused on possible differences related to task analysis (i.e., strategic planning) and self-observation(monitoring) processes. The second aim was to assess the relationship of observed strategies with self-reported and behavioral indices of self-regulated learning.

The self-controlled practice behaviors observed in the current study suggest that students of similar age, performance level and education level spontaneously adopted different self-regulated learning strategies during self-controlled practice. That is, we gauged self-controlled practice behaviors and determined underlying strategies by comparingcorrelations between practice scores and subsequent distances (i.e., task difficulties) at which students practiced the aiming task.The Distance-group showed a strong correlation between consecutive practice distances. Accordingly, these students behaved consistent with a strategy in which they had systematically planned their practice beforehand. The very weakcorrelation between previous score and change in practice distance showed they did not effectively align practice distance with their performance level. Instead, these students increased or decreased practice distance (and thus task difficulty)regardless of their success-score.The Score-group, by contrast,behaved consistently with a strategy in which they planned and monitored performance and adjusted playing distance based on their performance monitoring. Students in this group showed strong correlationsfortheir previous actual score and change in practice distance.These students showed effective performance monitoring by self-observation and adjusted task difficulty (i.e., practice distance)as effective self-regulated learners are proposed to according to the social cognitive model of self-regulated learning (Zimmerman, 2000). Finally, for the Other-group practice distance showed only weak or no correlationswith previous score and previous distance respectively.Students in the Other-grouppresumably displayed several unidentified strategies or they applied no strategy at all.An explanation for this could be that some novice learnersfocus on task execution rather than monitoring their performance and adjusting practice distance (Ianovici& Weissblueth, 2016). Further research could clarify whether task focus interferes with strategic planning and contribute to the identification of a broader range of practice strategies that can be discerned during practice. For now, this group is disregarded for further discussion.

According to social cognitive model of self-regulated learning (Zimmerman,2000), individual differences in self-regulatedpractice behaviormay reflect different levels of development of,or engagement incomponents of the self-regulated learning cycle.To our knowledge, previous research has typically used self-reported measures to identify these self-regulation processes. By contrast, behaviors during self-controlled motor practice have not been directly assessed to reveal the purported useof task analysis and self-observation components of self-regulated learning.Kolovelonis, Goudas and Gerodimos(2011) and Kolovelonis et al. (2012) did, however, demonstrate that performance monitoring improved performance. Yet, these authorsimposed a practice routine that included performance monitoring instead of assessing whether it spontaneously emerged.

The current study did focuson the spontaneousoccurrence of practice strategies in order to assess the processes underpinning self-regulated learning, but did not examine the ensuing consequences for performance and learning. Future research must incorporate additional motor performance and learning measurements to determine the effectiveness of observed strategies. It is speculated, however, that since the Score-group did not only systematically plan but also monitor practice results relative to task difficulty, and thus seemingly showed more effective self-regulated learning than the Distance-group, they would demonstrate superior learning outcomes.

The second aim of this study was to assess to what degree the different practice strategies relate to differences in indices of self-regulated learning.Given that competence seemingly is distributed across phasesand components of self-regulated learning,we anticipated that a strategy that consists of strategic planning and self-observation,as applied by the Score-group,would be associated with higher levels of motivational beliefs and observed behavioral indicators for self-regulated learning than for a planning only strategy as applied by the Distance-group.Contrary to thisexpectation, no significant differences were found between groups for self-efficacy and motivation.In fact, only prediction biasproved to be different between the Distance-group and the Score-group. The Distance-group, like the groups that were assigned process goals in the experiment by Kolovelonis et al. (2013), underestimated performance. The Score-group however, overestimated performance, which is in accordance with studies that show that children typically overestimate performance in risk free tasks (Almeida et al., 2016, 2017). Although all children received the same performance goal prior to the self-controlled practice session, children in the Distance-group more often practicedat larger distances that were clearly too difficult to succeed. Practicing at large distances may have resultedin a more critical appreciation of their skill level andlower predictions than typically seen in children (Almeida et al., 2016, 2017; Kolovelonis et al., 2013). It is perhaps not coincidental that prediction bias was the only index of self-regulated learning that was obtainedwhile the children practiced. In this respect, it may be argued that prediction bias more likely reflectsa state-likeperformance belief,as opposed tothe more stable trait-like performance beliefs(i.e., self-efficacy and motivation). In terms of the constraints-led approach, one could argue that prediction bias and self-regulated learning strategyemerge under the influence of joint constraints during practice. Self-efficacy and motivation on the other hand, develop on longer time scales and may therefore be less clearly related to the observed self-regulated learning strategies. In fact, making performancepredictions before every block of five trials during practice, may have partly instigated the students within the Score-group to monitor their performanceand to make strategical adjustments ofpractice distance or difficulty (Cleary et al., 2006; Kolovelonis, Goudas & Dermitzaki, 2011; Renshaw et al., 2010).This observation suggests that, at least for novices, actual self-controlled taskengagement (i.e., processing relevant information while being engaged in the performance phase of self-regulated learning)is pertinent to distinguish between different self-regulated learning strategies.It further supports the notion that the application of self-regulated learning strategies may be highlytask-specific (Cleary et al., 2012; Miller & Brickman, 2004). Self-controlled practice of the novel aiming task used here, evokedstrategic planning and self-monitoring behaviorfor students in the Score-group. This group showed spontaneous self-regulated learning without explicit instructions regarding their practice strategy. This finding stresses the pivotal function of self-controlled practice during the performance phasein order to allow the emergenceand development ofself-regulated learning strategies. Anotherpossible explanation for poor generalization of the motivational belief variables to the observed self-regulated practice strategies may be that inaccurate self-reportingcould have affected the ratings of self-motivational belief variables(Jonker et al., 2011; Kermarrec et al., 2004; Zimmerman, 2008). In addition, the students'limited experience with the task before being queried on their motivational beliefs (i.e., only a few minutes of familiarization) may be another factor that limits the sensitivity of self-reported self-efficacy and motivation as indicators of self-regulated learning strategies.

Conclusion

This study showed that self-controlled practice elicited different observable self-regulated learning strategiesin students whopractice a novel aiming task in PE. The observed strategies indicate individual differences in the degree to which students usetask analysis and self-observationto regulate practice.The Score-group monitored performance and adjusted practice distance relative to their performance. The Distance-group, however, planned practice distance and adhered to that planning regardless of their performance. Both groupscould also be discerned by differences in accuracy of estimated score, suggesting that practice strategy and estimated score are influenced by joint constraints during actual self-controlled practice.

The findings are relevant for the design and implementation of self-regulated learning interventions for students practicing new motor activities in PE classes and,more general, sports settings. PE teacherswho aim at the progression of self-regulated learning skills may considerfacilitating planning and monitoring by invoking self-controlled practice.For those students who do not spontaneously engage in strategic planning and self-monitoring, teachers may incorporate stimulation of these processes in teaching.

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