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Autonomy-supportive behaviors promote autonomous motivation, knowledge structures, motor skills learning and performance in physical education

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Abstract Previous research provides evidence as to the influence of teachers' autonomy-supportive behaviors on students' autonomous motivation in physical education (PE). However, few studies have considered the impact of teachers' autonomy-supportive behaviors on enhancing knowledge structures and motor skills learning in PE. The present study investigated whether an autonomy-supportive intervention designed to promote motor skills learning (experimental group), compared with conventional teaching (control group), would increase autonomous motivation, knowledge structures, skill learning, and performance and whether it decrease controlled motivation in students over a semester. Twenty-eight PE students participated in this quasi-experimental study. Badminton skills were assessed in pre and post intervention and retention sessions. Motivational regulations and knowledge structures were measured in pre and post intervention. In a session after the retention, game performance was measured on the transfer test. Overall, the experimental group and the hypothesized process model were supported. The experimental group demonstrated greater mean scores in some skills in post and retention tests. Compared to students in the control group, students in the experimental group reported greater autonomous motivation and game performance in the post-test. Furthermore, knowledge structures in both groups improved. Promoting skill learning in an autonomy-supportive way, compared with conventional teaching, has important practical implications for PE programs. We conclude that the intervention was successful in enhancing students' autonomous motivation and performance.

Keywords Autonomy-support · Self-determination theory · Constraints-led approach · Skill learning · Game play performance

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Introduction

There has been a surge of research interest in improving students' performance through motivational styles in physical education (PE, e.g., Aelterman et al. 2012; Reeve and Jang 2006; Taylor et al. 2010; Vansteenkiste et al. 2004). Research has shown that when social contexts support students' self-determination, it results in better performance than non-supporting environments (Deci and Ryan 2000; Ryan and Deci 2000, 2017). However, previous research could be said to suffer from a number of limitations: (i) it does not assess game performance, (ii) it does not distinguish performance from learning and knowledge structures, (iii) and it also suffers from a lack of an effective intervention for enhancing motor skills learning and performance. In the current study, we aimed to investigate an intervention designed for enhancing skill learning, performance, knowledge and motivation in PE based on the tenets of self-determination theory and the constraints-led approach, using a quasi-experimental study design.

Self-Determination Theory

Self-determination theory (SDT, Deci and Ryan 1985, 2000, 2008; Ryan and Deci 2000, 2017) is theory of human motivation and personality, which has received empirical support in the PE domain (e.g., Haerens et al. 2015; Jang et al. 2016a; Jang et al. 2010). Based on SDT, social contexts play a crucial role in students' psychological needs (i.e., autonomy, competence, and relatedness), motivational regulations, performance, and engagement in activities. That is, teachers' interpersonal behaviors, through supporting versus non-supporting students' self-determination, can have a significant impact on students' outcomes.

Teacher Interpersonal Behaviors

Based on SDT, autonomy-supportive behaviors relate to students' positive outcomes such as adaptive behaviors and skill development in PE (e.g., Behzadnia and Deci 2017; Cheon et al. 2012; Vansteenkiste et al. 2004). Autonomy-supportive behaviors are obvious when teachers acknowledge students' perspectives and nurtures their inner motivational resources (Deci et al. 1994), use informational and non-controlling language (Koestner et al. 1984), provide positive and competent feedback (Ryan and Deci 2000), teach in the students' preferred ways (Jang et al. 2016b), and provide explanatory rationales (Reeve et al. 2002). In this approach, the role of the teacher is facilitating learning processes by supporting students' intrinsic motivation. Research has shown that autonomy-supportive behaviors positively affect students' intrinsic motivation and performance (Cheon et al. 2012; Vansteenkiste et al. 2004).

In contrast, with controlling teaching styles, teachers use overt controlling strategies, demanding language, as well as push students to behave in particular ways (Deci and Ryan 2000; Reeve and Jang 2006; Soenens et al. 2012). Research has shown that controlling teaching styles affect students' negative outcomes such as less learning and maladaptive behaviors (Haerens et al. 2015; Ryan and Deci 2017). Thus, when teachers do not consider students' choices, students' intrinsic motivation decrease, and they are unable to internalize the learning activities – that is they fail to fully internalize extrinsic motivations. In other words, teachers' controlling behaviors would enhance students' controlled motivation, and thus results in disengagement, dropping out, and less well-being (Ryan and Deci 2017).

Autonomous and Controlled Motivation

According to SDT, behaviors are guided by different types of motivation ranging from autonomous motivation to controlled motivation and amotivation. Amotivation refers to the lack of motivation to do activities. Controlled regulation refers to external pressures such as expectation imposed by others or internal pressures such as anxiety and ego-involvement. On the other hand, autonomous motivation refers to engaging in an activity out of interest, pleasure and/or by valuing the importance of the activity (Deci and Flaste 1995; Deci and Ryan 1985, 2008; Ryan and Connell 1989).

These regulations direct behaviors but they result in different outcomes (Ryan and Deci 2017). Ryan and Deci (2017) demonstrated that promoting students' autonomous motivation can result in effective performance. Research has generally shown that autonomous motivation relates to positive outcomes such as adaptive behaviors and effective performance (Deci and Ryan 2008; Keshtidar and Behzadnia 2017; Mouratidis et al. 2008; Sarrazin et al. 2002). In contrast, controlled forms of motivation relate to negative outcomes such as less intention to do physical activities (Wang et al. 2016).

In this study, the authors also aimed to integrate the SDT with the constraints-led approach (CLA), which has received empirical support in the motor skills development domain (Chow et al. 2013; Davids et al. 2008; Lee et al. 2014), to delivery of instructions in PE classes. We specifically aimed to create a new autonomy-supportive teaching style not only for enhancing students' motivation and knowledge but also for improving their sport skills; this is based on SDT and the CLA perspectives.

The Constraint-Led Approach

The CLA, which is based on dynamic systems theory and ecological psychology, proposes a framework for understanding learning designs in PE (Davids et al. 2008). From this approach, the important methods to enhance motor learning include: (i) emphasis on discovery learning through becoming active learners as autonomous learners in their learning activities, (ii) manipulating main constraints (i.e., learner, environment, task) in order for the emergence of the specific motor behaviors and enhancing learners' self-organizing learning, (iii) providing affordances in game-play environments to enhance information-movement couplings to enable learners to get the desired skills, (iv) emphasizing the movement variability that is the emergence of behaviors under dynamic interaction between key constraints over time by various movements, (v) emphasizing unique optimal movement patterns for each learner because of the intrinsic dynamic existing in each individual as well as learning styles and prior experiences, and (vi) considering individuals' intrinsic dynamics because there are individual differences in the acquisition of motor skills even when the learners are given the same task (Chow et al. 2007; Chow et al. 2011; Davids 2012; Davids et al. 2006; Gibson 1979; Kelso 1995; Newell 1986; Seifert et al. 2013; Seifert et al. 2014; Thelen and Smith 1996).

The CLA is a pedagogical approach based on learners considered as nonlinear dynamical systems (Chow et al. 2011; Davids et al. 2008; Renshaw et al. 2010). That is, adapting CLA would meet the motor skills learning needs of learners (see Chow et al. 2015). However, only considering the motor skills learning needs of learners is not enough for engaging them in learning programs. Based on SDT, the practice sessions should support learners' psychological needs and their autonomous motivation in order to actively engage them in learning activities (Ryan and Deci 2017).

Integrating SDT and the CLA

The frameworks of both SDT and the CLA emphasize that learning environments affect individuals' performance, and the requirements of such performance differences are basically due to the quality of practitioner-learner relationship. General convergence of both SDT and the CLA suggest that when the learning environment are supportive of learners' autonomy, it provides the basis for positive outcomes such as skill development and better performance (Chow et al. 2015; Ryan and Deci 2017).

Through autonomy-supportive behaviors, practitioner supports students' basic psychological needs and self-determination so that it would result in students' better performance (Cheon et al. 2012; Ryan and Deci 2017; Vansteenkiste et al. 2004). When teachers give students the freedom to find the best way to learn skills through exploratory behaviors, students may enjoy this freedom to be intrinsically motivated for the activities (Renshaw et al. 2012). Experimental research has also showed that, generally, teaching based on the CLA elements can enhance students' self-determined motivation compared to the traditional teaching approach (Moy et al. 2015). Lee et al. (2014) also showed that emphasis on individual differences, an important element of the CLA, in learning designs has a significant effect on performance. Using SDT and the CLA perspectives may prove useful for researchers and teachers to create effective learning environments in PE either in school (e.g., Cheon et al. 2012; Jang et al. 2016b) or college students (Moy et al. 2015).

Traditionally, in the motor skills acquisition domain, teachers used conventional practice designs, such as learning technical skills in isolation from the game performance context and repetitive practice (Anson et al. 2005; Hopper et al. 2009). In educational domains, generally, teachers used controlling teaching styles through offering extrinsic incentives, looking for students' specific desired behaviors, and using punishment such as low grade (Reeve 2009; Reeve et al. 2014).

In the current study, the authors integrated both perspectives so that the teacher applied the SDT guidelines such as establishing a relationship with students and supporting their self-determination in practice sessions, then the teacher applied the CLA guidelines such as encouraging students to engage in creative behaviors and providing positive feedback in teaching motor skills. We therefore compare motivational regulations, knowledge structures, skill acquisition, and game performance in the experimental group and conventional teaching style group (control group), as detailed below.

Skill Development

Research has established that autonomy-supportive behaviors lead to autonomous motivation and positively predict students' learning (Cheon et al. 2012; Vansteenkiste et al. 2004). Cheon, Reeve and their colleagues (Cheon and Reeve 2013, 2015; Cheon et al. 2012) developed a new autonomy-supportive intervention to enhance students' autonomous motivation, engagement, and skill development in PE classes. The results of their study showed that autonomy-supportive behaviors positively enhanced students' autonomous motivation, engagement, intentions for future physical activity and perceived skill development in PE programs when compared with students in the delayed-experimental groups. However, the major limitations of their studies were related to assessment of skill development. That is, they did not distinguish between the different sports in PE programs and used self-report instruments to measure students' skill development. It would be preferable to distinguish sport skills in PE and use observational methods to assess skills learning.

Moreover, previous research examining the role of autonomy-supportive behaviors toward skill learning did not necessarily examine sport skills in relation to PE programs (Hooyman et al. 2014; Wulf et al. 2014). Skill learning is complex and takes time (Gréhaigne et al. 2005), and therefore it is preferable to examine the effects of interpersonal teaching styles in skill learning in long-term interventions.

Performance

In this study, the authors distinguished skill learning from performance because skill learning refers to learning specific fundamental skills that are important for game play performance. In other words, considering only skill development would not necessarily demonstrate a good performance. Further, skill learning is a basic element/step for good performance, and skill learning programs should transfer to the main game play performance environments (Davids et al. 2008; Schmidt and Lee 2011). In this way, we could also evaluate the ecological validity of skills in the actual performance environment. Additionally, it is preferable to measure students' performance in more details in PE. That is, students' performance assessment should evaluate their base, skill executions, and their decision-making abilities during game play. Therefore, students' performance should reflect the effectiveness of skills they learned, how they can perform the skills learned, and how they can use the skills learned in a real game situation, like competition (Mitchell and Oslin 2006; Oslin et al. 1998).

Understanding how teachers' interpersonal behaviors relate to both motor skill acquisition and game performance in PE is crucial. Based on SDT (Ryan and Deci 2017), autonomy-supportive behaviors are either process-focused or outcome-focused. That is, paying attention to only outcome-focused goals or rewards may yield negative outcomes such as superficial learning. Thus, in the current study, the authors expected that autonomy-supportive teaching style positively affect both students' skill acquisition processes (the process-focused goal) and their game play performance (the outcome-focused goal), compared with conventional teaching style.

Knowledge Structures

SDT postulates that autonomy-supportive behaviors are related to students' positive outcomes, such as learning (Ryan and Deci 2000, 2017). Research has also revealed that autonomy-supportive behaviors positively relate to students' engagement, motivation and psychological well-being in the PE domain (Cheon et al. 2016; Jang et al. 2016a; Taylor et al. 2010). Furthermore, one of the most important goals of PE is promoting students' knowledge structures (McGee and Farrow 1987; Wuest and Bucher 1999). Therefore, it would be crucial to examine how teachers' interpersonal behaviors affect the development of knowledge structures in PE programs.

In the motor skills acquisition domain, learner's knowledge structure is an important element in motor skills learning – that is, the greater and more varied the knowledge structures, the greater the decision-making and the better sport performance (Williams et al. 1999). Research has also shown that expertise in sports performance is a result of interacting between high skill executions and knowledge structures (Abernethy et al. 1993; French and Thomas 1987; McPherson and Thomas 1989). Anderson (1987) postulated that there are two important sources of knowledge: procedural and declarative. Procedural knowledge describes 'how to do' something, for example: how to play a *smash* or *drop shot* in badminton. Declarative knowledge describes 'what to do' and refer to knowledge of a specific situation or task. Studies in the area of skill learning and performance revealed that developing both declarative and procedural knowledge types are associated with motor skills learning and enhancing performance (Arias et al. 2011; Del Villar et al. 2004; French et al. 1996; Williams and Ward 2003).

In this quasi-experimental study, the authors also aimed to examine the effects of teachers' interpersonal behaviors on students' knowledge structures or their cognitive development. Research has shown that autonomy-supportive behaviors positively affect students' engagement (Cheon and Reeve 2013), so that more involving in PE activities may also result in cognitive development and deep learning. Furthermore, in SDT (Deci and Ryan 1985; Ryan and Deci 2017), intrinsic motivation for activities are important for the integration of knowledge and cognitive development. Therefore, in this PE based study, we expected that autonomy-supportive teaching style not only affects students' autonomous motivation, skill learning and performance but also affects students' knowledge structures, compared with the conventional teaching style.

Aim of the Study

The present study was conducted, through a quasi-experimental study design, on two groups of students learning sport skills (i.e., badminton skills) either with an autonomy-supportive skill-learning intervention (experimental group) or with a conventional teaching style (control group) in PE classes among a sample of Iranian college students.

In Iranian educational system, PE is an obligatory course in university, like that of North American high school PE classes – the main aim of which is promoting social, emotional and physical health through either physical activities or their related conceptual learning (Wuest and Bucher 1999).

We specifically aimed to investigate whether the autonomy-supportive skill-learning intervention, compared with conventional teaching, increases autonomous motivation, knowledge structures, skill learning and performance, and decreases controlled regulation in PE.

Thus, the study's hypothesis was: *Motivational regulations, knowledge structures, skills learning, and performance would improve in the experimental group compared to the control group.*

Method

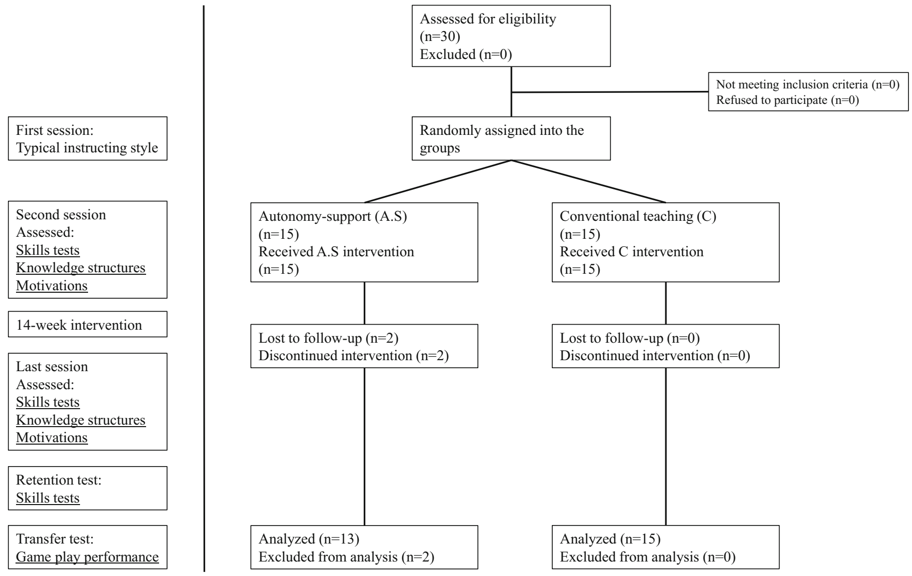
Participants and Setting

The study design was quasi-experimental. Thirty male PE students with a mean age of 21.02 years (SD = 1.58) participated in the study. We asked the students to report their experiences in playing badminton because we aimed to teach badminton basic skills to measure the variables employed in the study, and none of them had any badminton experience. The confidentially and anonymity of the data was ensured. After obtaining informed consents from all students, they were randomly assigned to either an experimental (intervention: autonomy support, n = 15) or control (conventional teaching, n = 15) group. Two of the participants did not complete the study (see Fig. 1).

Design and Procedure

Participants were informed that the study aimed to examine the effects of badminton teaching style on skills learning in general – they were blind to teaching approaches and study

Fig. 1 Participants flowchart, and the assessing times



hypothesis. The study consisted of a pre-intervention session, followed by a 14-week of intervention over a semester, a post-intervention session, a retention test conducted one week after the intervention, and a transfer test three days after the retention test.

The learning sessions were held twice a week in the mornings. Instructions in the first session (pre-intervention session) followed a conventional instructing style, the same for both groups (discussed the history of badminton, general rules and instruments, such as rocket and shuttle). In total, each group attended 28 class sessions; the interventions started from session two; two sessions were also included as pre and post test sessions (the acquisition period), when we assessed four badminton skills. Motivational regulations and knowledge structures were measured in the second session and the last session by the pre and post interventions. In a session after the last session, the skills were again assessed (i.e., retention test). In a session after the retention test, game play performance was assessed on the transfer test (i.e., far transfer).

The class programs in both conditions were almost identical (about 20 minutes of warm-up /cool down and about 60 minutes of badminton training). Sessions in both conditions were run by the same teacher (i.e., a professional with four years of teaching-instructing experience in badminton) who was familiar with autonomy-supportive teaching and the constraints-led approach as well as conventional teaching style.

Intervention

Table 1 presents the interventions for both the experimental and control groups. Both instructions, autonomy-supportive teaching (Cheon and Reeve 2015; Cheon et al. 2012; Reeve and Cheon 2016) and the CLA (Chow et al. 2011; Davids et al. 2008; Moy et al. 2015; Renshaw et al. 2012), were adopted from previous research which we integrated for skill learning in PE. Besides specific behaviors and instructions in the experimental group, practice sessions were well-organized and understandable and clear action plans and goals were provided by the teacher before each lesson. In the control group, the teacher used a conventional teaching style during PE classes. This group neither received autonomy-supportive intervention nor the constraints-led approach intervention designed for the experimental group (Table 1).

To confirm the fidelity of each approach, the teacher piloted a semester of badminton lessons with two classes unaffiliated with the current study. Some lessons were observed and validated by three experts in the SDT, the CLA and teaching badminton. The validation of the intervention was accomplished with checklists with the main instructional features for each expert indicated separately – one for the SDT expert, one for the CLA expert and one for the coach. The implemented lessons of the current study used the same checklist.

Tasks

The teacher tested four skills in the pre, post, and retention sessions. Reliability of skill tests in this study was established using Spearman-Brown coefficient method, which varied from .61 to .67. To measure game play performance, participants were assigned randomly to a prearranged order of game test prior to transfer testing,

Table 1 Instructions in the experimental and the control groups

Groups	Instructional behaviors	Sample instructions
Experimental	Provide choice	The teacher support students' choice and freedom and their decisions on how to do practices; give time to practice through exploratory behaviors in order to find the optimal way to do tasks; supports students' preferred ways; and organizes students' activities in a way that they prefer.
	Provide meaningful rationale	The teacher introduces the class activities by resource-providing and student-centered instructions; uses flexible perspectives pertaining to tasks and rules; provides rationale related to task limits and rules (e.g., to explain why a rule exists); simplifies and manipulates task (e.g., net height, rules and different equipment) and environment (e.g., dimension of court) constraints; and provides structure by communicating clear expectancies with explicit directions to guide students.
	Perspective-taking	The teacher displays patience to solve problems (i.e., how to find solutions; behavioral self-organization); respects students as autonomous individuals; and takes their suggestions on when they want to start and when they want to stop practices, when they would like to play game, and how they would prefer to do their practices.
	Informational and encouraging language	Using informational languages; the teacher allows students' interests and preferences to guide their classroom activities; uses a nondirective utterance to guide students; encourages creative behaviors by some positive statements (e.g., "you may" or "you can" rather than "you have to" or "you must"); and simply asks students "what do you want rather than tells them "what to do and how to do it .
	Acknowledge student feelings	The teacher asks what students want or desire (e.g., are you ready?); acknowledges their feelings about the tasks; avoids controlling behaviors and ego-involvements as well as accepts expression of negative affect; listens and asks questions related to skills learning, rather than only teaching, makes a good relationship with students; tries to understand and accept each students' learning styles; and acknowledges the difficulties and minimizes any pressure resulting from skills.
	Positive feedback	The teacher provides positive feedback (non-controlling and non-directive feedback) on how students perform; and gives opportunities to make decisions about the delivery of feedback of how they want to learn.
Control	Conventional practice design	The teacher introduces the class activities in a conventional practice design that starts with warm-up and then teaching technical skills in an isolation practice from the main plays in PE; the teacher tries to keep students on lessons and students should do all practices as they are supposed to do; students need to follow the directions provided by teacher, and emphasis on repetitive practices that introduced by teacher.
	Seeking for optimal patterns	The teacher seeks optimal movement patterns among each student which all students should aspire to; students need to obey the assignments; the teacher pushes students into doing practices based on his insights.
	Verbal communication	The teacher uses verbal communications and feedbacks in order to enable students quickly communicate on how they should perform movement skills; the teacher corrects students who stray off, saying "now is the time for work and not for playing or straying off".
	Provide rewards	The teacher uses the incentive and privileges in order to motivate students; when students provide the right answers and doing only based on teacher's directions, the teacher provides high scores; the teacher also uses the low scores as the punishment when students do not follow his directions.

and a coach (an experiment coach − external examiner) evaluated participants' performance during game play.

Serve

The Pool Long Serve Test (Johnson and Nelson 1986) was used to assess serve skill. Students were asked to serve from the right service court to the right and the end of the receiver's court. Scoring zones were marked in 16-inch. areas starting from the two inches behind the baseline. Point values were assigned to the five zones (beginning of the baseline was given the highest value) were five, four, three, two and one, respectively.

Clear

The Pool Forehand Clear Test (Johnson and Nelson 1986) was used to assess clear skill. Students were asked to stand at the center of the court, two and a half feet from the baseline. We modified the test measure form, whereby teacher hit shuttles to the desired location with an appropriate trajectory to the participants (using the clear across the net to the mentioned zone), and they must have hit the shuttle using the forehand clear to four scoring areas on the other side of the net. Students were asked to throw the appropriate shuttles that they received; thereafter, the teacher evaluated students' hits. Higher point scores were associated with a deeper landing location of the shuttle at the end of the court. Point values were assigned to the four zones ranging from 1 (lowest point) to 4 (highest point).

Smash

The Badminton Smash Test (Johnson and Nelson 1986) was modified from a badminton set-up machine (French et al. 1996) for testing by a teacher who assessed smash skill. The teacher hit shuttles (across the net) to the desired location with an appropriate trajectory to students (similar to the clear test). Students were required to stand at the center of the court and hit a smash into one of the two 4 feet, 4-inch-wide target areas on each side of the court. Higher point scores (2 points) were associated with landing location of the shuttle within one of these targets, and shuttles landing within court boundaries received a score of 1.

Drop

To test drop shot, the teacher fed shuttles to students, similar to the smash test (French et al. 1996). Each student was asked to stand near the center of the court, and return shuttles using an overhead shot over the net into target zones. Trials that landed just over the net into one of two 3-feet × 3-feet target areas located in the front corners of the court received a score of 3, whereas shuttles landing in front of the service line at the center of the court received a score of 2. Trials where the shuttle hit the top of the net, but did not go over received a score of 1.

Measures

Game Performance

Students' game performance was evaluated in the transfer test session using the Game Performance Assessment Instrument (GPAI, Oslin et al. 1998). We adapted the GPAI to badminton, based on Mitchell and Oslin's (2006) study. Observations were based on time for about 15–20 minutes until an evaluation could be made by the coach, rather than only a number of trials. The instrument consisted of three components/criteria: *skill execution* (proficiently executes chosen skills - *clear* goes deep, *drop* is short, *smash* is hard and down), *base* (return to a base position between attempts - appropriate position at mid court – home position), and *decision making* (makes appropriate selects about which skills should use – *serve*: to push/bring opponent back/forward; *clear*: to push opponent back; *drop shot*: to bring opponent forward; or *smash*: to kill the point). The GPAI was assessed using a 10-point scale ranging from 10 (Very effective performance) to 1 (Very weak performance).

Knowledge Structures

Knowledge structures were measured through knowledge test questions for badminton developed by McGee and Farrow (1987), which comprised of procedural (25 items) and declarative knowledge (20 items). Questions from the *rules* (i.e., history, terminology, etiquette, rules, scoring), *techniques* (i.e., serve, clear, drop, smash and their receptions – positions of racquet and body) and *strategy* (i.e., defensive and offensive strategy) sections that concerned single play were selected. Three expert judges, including a teacher with six years of badminton teaching in the university and two researchers with two and five years of badminton teaching experience, confirmed that the questions reflected the aims of the unit and therefore provided additional evidence of content validity for the questionnaire.

Motivation

Students' motivational self-regulation was measured through the Learning Self-Regulation Questionnaire (SRQ-L, Black and Deci 2000). The scale measured two types of motivation; autonomous motivation (five-item: e.g., 'Because it was interesting to learn more about the nature of PE), and controlled regulation (seven-item: e.g., 'Because a good grade in PE was looked positive on my record'). The items were rated from 1 (*not to all true*) to 7 (*very true*). The validity and reliability of the original version of this scale (Perceived Locus of Causality; Ryan and Connell 1989) had been measured in an Iranian sample (Behzadnia et al. 2017). In the current study, inter-item correlation for one item in autonomous motivation subscale illustrated low correlation, thus it was removed from further processing. After that, the Cronbach alphas (Cronbach 1951) were calculated which were found to be satisfactory for both autonomous (α = .62) and controlled regulation (α = .74).

Data Analysis

Analyses were carried out with PASW (formerly, SPSS) 19.0. The study followed a 3 (time: pre, post, and retention) × 2 (groups) factorial design. A mixed- design ANOVA with repeated measures was conducted to determine differences within and between groups in the four dependent variables: *serve*, *clear*, *smash* and *drop* tests. The LSD adjustments test was used to further analyze the main effects and interactions to determine the location of differences within (sessions) and between (groups) factors. The multivariate analysis of variance (MANOVA) was conducted to assess game performance differences between groups. Finally, two separate repeated measure ANOVA were conducted to determine differences within and between groups for declarative and procedural types of knowledge and motivations. Pairwise comparisons were also used to determine differences within groups. Effect sizes were calculated using partial eta squared (η^2).

Results

There were no significant differences between the experimental and control groups in the pre-test measures.

Manipulation Checks

The systematic observation of classes was carried out by two experts in each approach and a badminton coach to verify that the key contextual, operational, and pedagogical requirements of each approach were present in the sessions (the same checklist described in the *Intervention*). They viewed and provided feedbacks on some lessons randomly in each group.

Skill tests

Table 2 presents descriptive statistics for badminton skills (serve, clear, smash, drop), motivations and knowledge structures for each group in each session.

During practice, skills generally increased across trials (from *pre* to *post* and *retention* tests) in each group. While the experimental group tended to have higher scores, the control group had the least scores during post and retention tests. Fig. 2 shows the nature of interaction effects on each skill.

In the *serve* skill test, the results showed a main effect for time, $F(2, 52) = 45.93$, $p < .001$, $\eta^2 = .64$, and time × group interaction, $F(2, 52) = 3.66$, $p = .04$, $\eta^2 = .12$. However, a main effect for group was not found. The main effect using LSD adjustments showed that both groups significantly increased their scores from *pre* to *post* test, the experimental: $p < .001$, Mean Differences (MD) = 1.71, the control: $p = .03$, MD = 1.09; and from *pre* to *retention* test, the experimental: $p < .001$, MD = 1.55, the control: $p < .001$, MD = .75. There was no significant difference from *post* to *retention* test in each group (Fig. 2a).

For the *clear* skill test, a main effect was shown for time, $F(2, 52) = 111.58$, $p < .001$, $\eta^2 = .81$, and group, $F(1, 26) = 5.59$, $p = .03$, $\eta^2 = .18$. These main effects were not qualified by an interaction between time and group. The main effect using LSD adjustments showed that both groups significantly increased their scores from *pre* to *post* test, the experimental: $p < .001$, MD = 1.69, the control: $p < .001$, MD = 1.47; and from *pre* to *retention* test, the experimental: $p < .001$, MD = 1.26, the control: $p < .001$, MD = .99. A significant score decrease was observed for both groups from *post* to *retention* test, the experimental: $p = .002$, MD = .43, and the control $p = .006$, MD = .48, (Fig. 2b).

For the *Smash* skill test, the results showed a main effect for time, $F(2, 52) = 28.90$, $p < .001$, $\eta^2 = .53$, and group, $F(1, 26) = 10.58$, $p = .003$, $\eta^2 = .29$. These main effects were not qualified by an interaction between time and group. The main effect using LSD adjustments showed that both groups significantly increased their scores from *pre* to *post* test, the experimental: $p < .001$, MD = .57, the control: $p = .003$, MD = .41; and from *pre* to *retention* test, the experimental: $p = .001$, MD = .52, the control: $p < .001$, MD = .41. There was no significant difference from *post* to *retention* test in each group (Fig. 2c).

Lastly, for the *drop* skill test, the results showed a main effect for time, $F(2, 52) = 27.82$, $p < .001$, $\eta^2 = .52$, and time × group interaction, $F(2, 52) = 3.20$, $p = .05$, $\eta^2 = .11$. However, a main effect for group was not found. The main effect using LSD adjustments showed that both groups significantly increased their scores from *pre* to *post* test, the experimental: $p < .001$, MD = 1.00, the control: $p = .03$, MD = .49; and from *pre* to *retention* test, the experimental: $p = .002$, MD = .62, the control: $p =. 05$, MD = .31. There was no significant difference from *post* to *retention* test in each group (Fig. 2d).

Game performance

Game play performance was assessed on the transfer test. The multivariate effect was significant by groups, Wilk's

Table 2 Means and standard deviations for each skill, motivation, and knowledge structures in each group in pre, post and retention tests

			Acquisition 1 (Pre-test)		Acquisition 2 (Post-test)		Retention	
Variables	Groups	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Skills								
Serve	Experimental	13	1.31	.55	3.02	.72	2.86	.89
	Control	15	1.41	.44	2.51	.67	2.16	.76
Clear	Experimental	13	1.68	.45	3.37	.33	2.94	.37
	Control	15	1.53	.52	3.00	.46	2.52	.65
Smash	Experimental	13	.68	.30	1.25	.32	1.20	.31
	Control	15	.52	.25	.93	.35	.93	.26
Drop	Experimental	13	.80	.37	1.80	.47	1.42	.26
	Control	15	1.00	.25	1.49	.35	1.31	.43
Knowledge Structures								
Procedural Knowledge	Experimental	13	5.77	2.92	8.69	2.63		
	Control	15	5.67	2.28	9.87	1.60		
Declarative Knowledge	Experimental	13	4.31	2.06	6.64	1.94		
	Control	15	4.13	1.55	6.00	2.33		
Motivations								
Autonomous Motivation	Experimental	13	5.71	.95	6.10	.49		
	Control	15	4.98	.95	5.40	.95		
Controlled Motivation	Experimental	13	5.40	.78	4.66	1.40		
	Control	15	4.85	1.24	4.80	1.05		

$\lambda = .69$, $F(3, 24) = 3.64$, $p = .03$, $\eta^2 = .31$. Univariate tests showed that there were significant differences between groups in the *base*, $F(1, 26) = 5.02$, $p = .03$, $\eta^2 = .16$, MD = .68, and *decision-making* $F(1, 26) = 7.60$, $p = .01$, $\eta^2 = .23$, MD = .79 components scores, whereby the mean scores of the experimental group were higher than the control group. There was no significant difference between groups in *skill execution*. Finally, the results showed significant differences between groups for overall game performance (the component of *base*, *skill execution*, and

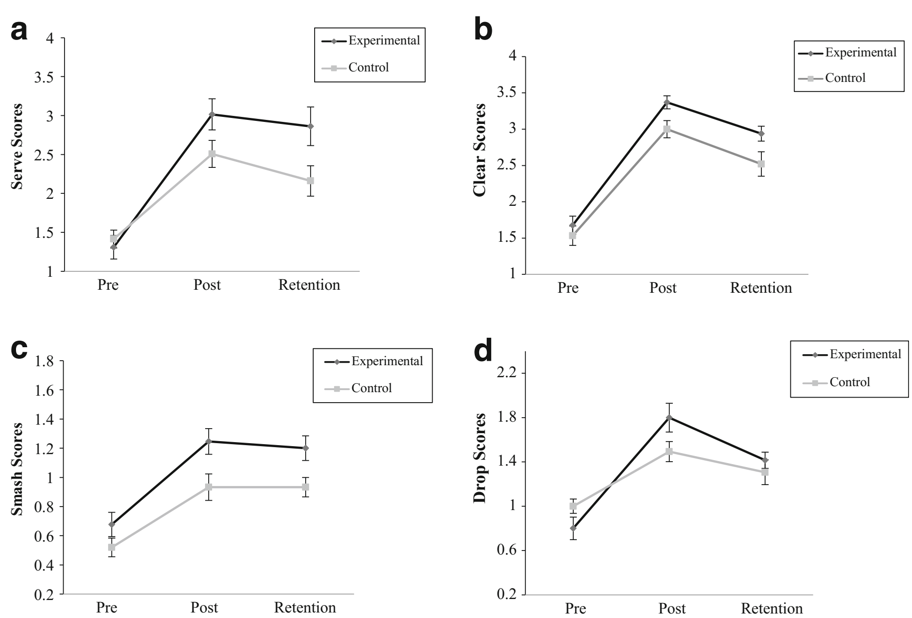
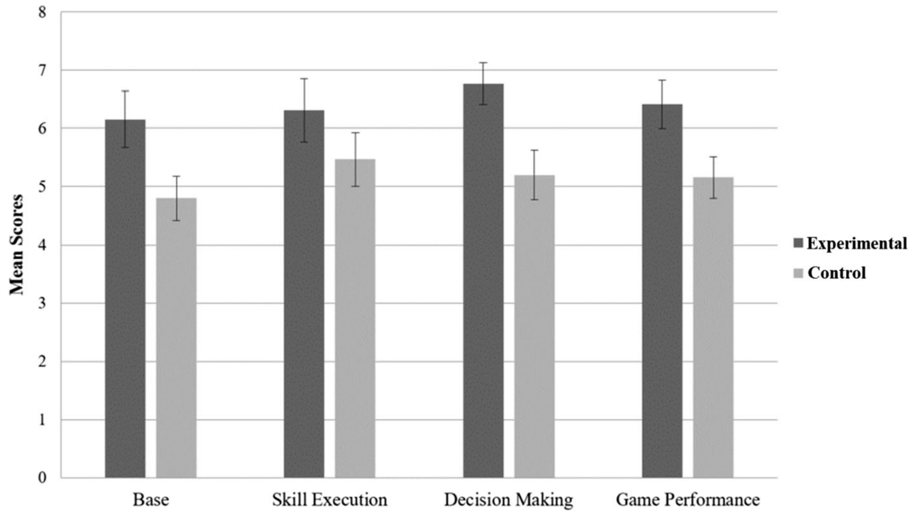


Fig. 2 Badminton skill tests during sessions in each group. Error bars represent standard errors

Fig. 3 Performance scores in each group. Error bars represents standard errors



decision-making), $F(1, 26) = 5.26$, $p = .03$, $\eta^2 = .17$, MD = .63. The pattern of results is shown in Fig. 3.

Knowledge Structures

Repeated measure ANOVA on procedural knowledge scores revealed only a significant main effect for time, $F(1, 26) = 51.81$, $p < .001$, $\eta^2 = .67$, but the main effects for group and interaction of time × group were not found. Declarative knowledge scores also revealed a significant main effect for time, $F(1, 26) = 14.98$, $p = .001$, $\eta^2 = .37$, but the main effects for group and interaction of time × group were not found. Pairwise comparisons showed significant improvement from *pre* to *post* test on both procedural (experimental: $t = 3.53$, $p = .004$, MD = 2.92; control: $t = 7.25$, $p < .001$, MD = 4.20) and declarative (experimental: $t = 2.72$, $p = .02$, MD = 2.15; control: $t = 2.74$, $p = .02$, MD = 1.87) knowledge types.

Motivation

Result of repeated measure ANOVA yielded significant effects for time $F(1, 26) = 4.67$, $p = .04$, $\eta^2 = .15$, and group $F(1, 26) = 6.93$, $p = .014$, $\eta^2 = .21$, but no significant effect for time × group interaction in autonomous motivation. Results of the repeated measure ANOVA yielded no significant effect of time, group, and interaction in controlled motivation. Despite increases in motivations in both groups, pairwise comparisons did not reveal significant differences from *pre* to *post* test in autonomous and controlled motivation. However, as expected, the experimental group, compared with the control group, yielded greater autonomous motivation in *post* test ($t = 2.39$, $p = .03$, MD = .70). The hypothesis regarding controlled regulation was rejected, and there was no significant difference between the experimental and control groups.

Discussion

The experimental test of autonomy-supportive skills learning-enhancing intervention, compared to conventional teaching, received support. The intervention positively affected students' skills learning and performance. While students in both teaching approaches did show some improvement in skill learning across time, students in the experimental group yielded better badminton skills than students who did not receive the autonomy-supportive intervention. That is, autonomy supportive instructional behaviors yielded greater skills learning than the conventional teaching group. The intervention led to greater autonomous motivation for skills learning in PE when compared to conventional teaching style. The intervention also improved knowledge structures, but there was no difference between the two groups.

The results of the present study showed that badminton game play performance in the autonomy-supportive intervention was higher than conventional teaching style. It was found that when students feel that their practitioner supports their choices and respects them as autonomous individuals (Ryan and Deci 2017), they show better performance. Additionally, viewing students through a nonlinear dynamic system resulted in better performance compared to a linear static system view (Davids et al. 2008). In other words, when the teacher shows flexibility in teaching and takes students' perspectives into account in PE programs, it results in enhancing students' performance compared with the conventional teaching style.

Previous research has found that the autonomy-supportive interventions enhance students' autonomous motivation and their performance (e.g., Cheon and Reeve 2013, 2015; Cheon et al. 2012). Consistent with such findings, the current study showed that autonomy-supportive skills learning-enhancing intervention positively affects autonomous motivation, skill learning, and performance, compared to conventional teaching style.

These findings also lend support to the idea that skill learning is facilitated when teaching conditions are supportive of students' decision making and their exploratory behaviors, enabling them to become active students. Furthermore, research literature has emphasized that learning may be enhanced when learners are given choices over when and what they practice and about aspects of the tasks (Lewthwaite et al. 2015), as well as increase in task difficulty based on the prior successes (Davids et al. 2008; Handford et al. 1997). Therefore, the present results appear to be among the first providing solid evidence regarding an autonomy-supportive intervention in the motor skills learning domain.

The Relation of This Intervention to Previous Research

The present autonomy-supportive skills learning-enhancing intervention differed from previous research. Firstly, previous research revealed that the CLA intervention resulted in enhancing students' intrinsic motivation and basic psychological needs compared to the traditional teaching styles (Moy et al. 2015). Secondly, Cheon and colleagues (Cheon and Reeve 2013, 2015; Cheon et al. 2012) showed that the autonomy-supportive intervention enhanced students' autonomous motivation, their engagement, and perceived skill development, and decrease amotivation in the PE classes. The fact that autonomy-supportive instructional behaviors enhance students' psychological factors and their perceived skill development and the CLA enhanced intrinsic motivation, are not enough for PE programs. Clearly, it would be preferable to run an intervention which not only affects students' autonomous motivation but also enhances students' motor skills learning and their actual performance. Moreover, it would be preferable to also assess students' game play performance after skill development resulting from autonomy-supportive behaviors to investigate the effects of interventions on students' game performance.

The idea of enhancing autonomy also is of necessity for students' positive targeted behaviors – and even in self-efficacy theory (Bandura 1989), autonomy is not considered a decisive factor in changing targeted behaviors. In this SDT-based study, we found that autonomy-supportive instructional behaviors provided the backdrop for students' positive functions.

It is also worth noting that the autonomy-supportive skills learning-enhancing intervention in the current study, which was compared with conventional teaching style, implies that enhancing students' self-determination and designing learning environments to enhance students' creative behaviors are important for their positive functions. That is because the conventional teaching style may enhance positive functions, but does not have as many benefits as the autonomy-supportive skills learning-enhancing intervention.

The Relevance for Education

The educational relevance of this study derives from the fact that the autonomy-supportive skills learning-enhancing intervention produced positive outcomes over a semester, compared with standard or conventional teaching style in PE programs. It thus has important implications for promoting positive functions. Moreover, because the intervention successfully enhanced positive outcomes in badminton in male students, it may also have implications either for enhancing other sports in PE programs or for female students, as SDT posits that supporting people's autonomy is important for their optimal functions regardless of gender (Deci and Ryan 2000).

Traditionally, teachers used the controlling behaviors, inflexible behaviors, punishment and reward to enhance students' performances in the educational domain while, in fact, teacher's control diminished students' functions (Deci and Ryan 2000, 2008). Moreover, in the skill learning domain, practitioners emphasized repetitive practice and sought for optimal movement pattern among the learners (Anson et al. 2005; Cothran et al. 2005; Moy et al. 2015). In contrast, from the SDT perspective, the important behaviors in the relationship between teacher and student, and from the CLA perspective, the important techniques in learning designs, as examined in this study, can present such alternatives.

Study Limitation and Future Directions

While knowledge structures in both groups significantly improved from pre to post intervention, the results did not show a significant difference between groups. Future research may give clues with regards to the effectiveness of this intervention in improving knowledge structures. However, the current study had limitations, and the authors suggest that the study be replicated with a large group of male and female students in relation to various sports.

Moreover, the present study controlled the major limitations of previous research – that is, they examined participants who had prior experience with the intervention (the CLA) (Moy et al. 2015), used short-term intervention research designs either in autonomy-supportive perspective (Hooyman et al. 2014; Wulf et al. 2014) or the CLA perspective (Lee et al. 2014; Moy et al. 2015), and assessed skill development using student self-reports (Cheon and Reeve 2015). Clearly, it is preferable to use participants who have no experience with the intervention. In this study, we tried to control the previous research limitations through including participants with no previous experience with the intervention, using a long-term intervention research design and assessing skill learning and performance through an observation tool scored by an external examiner. Longitudinal research acknowledges that learning is complex and takes time (Gréhaigne et al. 2005); therefore, this study also provides empirical evidence that the autonomy-supportive skills-learning enhancing intervention is an effective approach worth pursuing.

Conclusion

The current quasi-experimental study clearly showed that the autonomy-supportive skills-learning enhancing intervention would contribute to increased students' positive outcomes, compared with the conventional teaching style in PE. This study emphasizes the importance of teachers relating to their students in an autonomy-supportive way for PE students' promoted positive outcome.

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Compliance with Ethical Standards

Conflict of Interest Behzad Behzadnia declares that he has no conflict of interest. Hasan Mohammadzaded declares that he has no conflict of interest. Malek Ahmadi declares that he has no conflict of interest.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Animal Studies All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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