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A cluster-randomized controlled trial to improve student experiences in physical education: Results of a student-centered learning intervention with high school teachers

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ABSTRACT

Objectives: The purpose of this study was to investigate the effects of a teacher training program targeting the use of student-centered learning strategies—compared to a typical-practice, teacher-centered teaching style control—on physical education (PE) outcomes among high school students. *Design*: This investigation was following the CONSORT guidelines (2010) for a cluster randomized controlled trial.

Method: Australian students, aged 12–16 years (N = 554, M = 14.27, SD = 0.69), reported their motivation for PE, perceptions of teacher-derived psychological need satisfaction, in-class effort, and self-efficacy at baseline and follow-up (5 weeks later). Fidelity assessments were made at the mid-point of the intervention, whereby a blinded, trained observer coded teachers' implementation of student-centered learning strategies.

Results: Teachers in the intervention arm implemented student-centered strategies to a greater extent than those in the control arm. Linear mixed models revealed that over-time, relative to those in the control arm, students in the intervention arm displayed more positive change in autonomous motivation for PE, as well as in autonomy and relatedness need satisfaction, effort, and PE learning-efficacy.

Conclusions: Conceptually, these findings demonstrate that teacher training programs targeting the use of student-centered teaching strategies may be beneficial for promoting desirable motivational outcomes, and provide insight into the mechanisms responsible for these positive in-class effects (e.g., heightened need satisfaction). This study also offers important practical information for educators in terms of how to foster student-centered classroom environments.

High school physical education (PE) provides a large proportion of children and adolescents with valuable, structured opportunities for physical activity (McLennan & Thompson, 2015). Moreover, the benefits of positive experiences in high school PE include the encouragement of leisure-time physical activity (e.g., Chatzisarantis & Hagger, 2009), improved academic performance in school (e.g., Rasberry et al., 2011; Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012), elevated self-perceptions (e.g., self-esteem; Standage & Gillison, 2007), and enhanced social skills and well-being (e.g., Bailey, 2006; Janssen & Le Blanc, 2010; Lawson, 2005). The psychological constructs that underpin these 'positive experiences' are wide-ranging, but substantial research evidence has underscored the particular importance of students' motivation for PE (e.g., Owen, Smith, Lubans, Ng, & Lonsdale, 2014), confidence in PE (e.g., Jackson, Whipp, Chua, Pengelly, & Beauchamp, 2012), and indicators of engagement, such as effort and enjoyment (e.g., Lonsdale, Sabiston, Taylor, & Ntoumanis, 2011; Ntoumanis, 2005; Standage, Duda, & Ntoumanis, 2005).

There is a well-established literature documenting the strategies that may promote one or more of the aforementioned constructs (e.g., motivation, confidence). In some instances, recommendations or programs have been grounded primarily in pedagogical frameworks, such as the Sport Education model (e.g., Wallhead & Ntoumanis, 2004), physical activity- (e.g., Fairclough & Stratton, 2006) or health-based models (e.g., Haerens, Kirk, Cardon, & De Bourdeaudhuij, 2011), Teaching Games for Understanding model (see Chow, Davids, Button, Shuttleworth, Renshaw, & Araùjo, 2007), and the Pedagogical Content Knowledge model (Amade-Escot, 2001). In other cases though, intervention programs have been guided by psychological theory, including the use of motivational climate principles (see Braithwaite, Spray, & Warburton, 2011), self-determination theory (e.g., Sparks, Lonsdale,

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Dimmock, & Jackson, 2017), and/or social cognitive theory (e.g., Dishman et al., 2005; Lawson, 2005). Informed by this literature, our aim was to implement a teacher training program—based on well-established pedagogical (specifically, student-centered learning) methods—in order to improve key student outcomes (e.g., PE motivation, self-efficacy). However, with the aim of advancing our knowledge regarding the mechanisms responsible for such effects, we also drew from relevant psychological theory (i.e., self-determination theory) to provide insight into the psychological mediators of any student-centered learning effects.

Student-centered learning (see Land, Hannafin, & Oliver, 2012) is an umbrella term that characterizes several different pedagogical models, all of which are based on the principle of promoting students' self-directed, active involvement in the learning process. The notion of student-centered learning is well-established (see, for example, Anderson, 1990; Goodyear & Dudley, 2015; Rogers, 1989), and within the education literature, student-centered approaches have also been termed person- or learner-centered methods, as well as being referred to as explorative-, discovery-, cooperative-, active-, participatory-, or project-based learning (e.g., Baeten, Kyndt, Struyven, & Dochy, 2010; Brandes & Ginnis, 1996; Steiner, 2013). Several well-used PE pedagogical models have their roots in a student-centered philosophy, including Mosston's (1981) Spectrum Theory for physical education teaching, the Sport Education model (Siedentop, 1994), the Sport Education in Physical Education Program (SEPEP; Alexander, Taggart, Medland, & Thorpe, 1995), Teaching Games for Understanding (TGfU; Werner, Thorpe, & Bunker, 1996), the 'Game sense' model (Thomas, 1997a), the Tactical Decision Learning model (TDL, Gréhaigne, Godbout, & Bouthier, 2001), and 'play-teach-play' approach (Graham, 2008).

Despite some divergences in the operationalization of different student-centered frameworks, all are built on the common premise that "the only learning which significantly influences behavior [and education] is self-discovered" (Rogers, 1989, p. 302). That being the case, there are a number of broad commonalities that characterize student-centered learning strategies. First, decision-making responsibilities associated with planning, implementing, and evaluating activities are shifted, at least in part, from the 'expert' (teacher) to the 'learner' (student) (McPherson, 1993; Mosston, 1981; Siedentop, 1994). Second, teachers typically adopt a role as a facilitator (Metzler, 2011) or activator (Hattie, 2009) of learning, whose role is to encourage and support student ownership of the learning process. Third, students are explicitly encouraged to learn from (and instruct) other students through peer coaching and through peer working groups based on complementary interests or performance levels (Jenkinson, Naughton, & Benson, 2014; Whipp, Jackson, Dimmock, & Soh, 2015). Fourth, although teachers maintain a management and monitoring role, they encourage students to engage in their own reflective and creative thinking, and challenge students themselves to find solutions to problems (Lodewyk, 2009); a common recommendation in creating student-centered environments, for example, is for teachers to employ the 'questioning' technique (Bähr & Wibowo, 2012; Gilllies & Haynes, 2010). Finally, student-centered learning strategies emphasize the importance of teachers enabling each student to focus on individualized learning, empowering students to learn about their own development and skills, and to adapt their learning strategies accordingly (Beaten et al., 2010).

In their seminal review, Fraser and colleagues (Fraser, Wahlberg, Welch, & Hattie, 1987) demonstrated that student-centered learning strategies were associated with positive student outcomes, including greater participation, satisfaction, motivation to learn, and problem solving. Findings reported in more recent studies have corroborated the desirable cognitive, affective, and social outcomes that may result for students within student-centered learning environments, including improvements in critical and creative thinking, analytic reasoning, social and communication skills, and problem-solving capabilities (e.g., Goodman, 2016; Sin, 2015; Smit, De Brabander, & Martens 2014). Despite evidence to support the use of student-centered strategies, teacher-centered (or 'direct', 'reproductive' teaching) instructional styles appear to predominate in high schools (Biggs, 2007; Curtner-Smith & Hasty, 1997; Curtner-Smith, Todorovich, McCaughtry, & Lacon, 2001), and evidently, there is substantial scope to increase the use of student-centered approaches in PE.

Our aim in this investigation was to provide high school PE teachers with a training program designed to enable the effective use of student-centered learning principles. Aside from solely examining the student outcomes associated with this form of intervention (relative to a typical, teacher-centered control), however, we also sought to better understand *how* and *why* student-centered methods may account for favorable outcomes. In doing so, we aimed to integrate student-centered learning principles with those outlined in another well-established framework—specifically, those associated with the notion of need satisfaction and the motivational continuum described within self-determination theory (SDT; Ryan & Deci, 2000). According to SDT, an individual's motivation for a given activity may be characterized not only by its quantity, or level, but also by its *quality*. When experiencing higher-quality motivation, individuals may pursue an activity (such as PE) for autonomous reasons, such as (a) an inherent interest in, or enjoyment of, the activity (i.e., intrinsic motivation), (b) a feeling that the activity aligns with one's identity and sense of self (i.e., integrated regulation), and/or (c) an endorsement of the value or importance of the outcomes of the activity (i.e., identified regulation). On the other hand, individuals might participate in an activity in light of relatively more controlled motives, such as the desire to avoid feelings of guilt associated with non-participation (i.e., introjected regulation), and/or to avoid punishment or obtain praise from others (i.e., external regulation). Finally, it is also recognized within SDT that individuals may participate in an activity despite an absence of any motivational drive—this state is known as amotivation. A substantial body of literature has documented—both within and outside of PE—that more autonomous (relative to controlled) motivation is beneficial for students in terms of promoting desirable outcomes, including greater engagement, well-being, persistence, and achievement (see, for example, Hagger et al., 2007; Jackson, Whipp, Chua, Dimmock, & Hagger, 2013; Sparks et al., 2017).

As well as outlining the implications of desirable (i.e., autonomous) forms of motivation, SDT also details the ways through which social environments can be structured so as to support individuals' basic psychological needs, and in turn, stimulate more adaptive motivational regulations (see Niemiec & Ryan, 2009). In PE, a wealth of research has shown that, through their communicative and instructional styles, teachers are key agents in the creation of need-supportive educational environments (e.g., Aelterman, Vansteenkiste, Van Den Berghe, De Meyer, & Haerens, 2014; Haerens et al., 2013). There is evidence that controlling (as opposed to need-supportive) instructional styles may be commonly employed by teachers (e.g., Reeve, 2009); however, a number of intervention studies have shown that teachers can be trained to successfully integrate autonomy, competence, and relatedness need-supportive practices within their instruction (e.g., Cheon, Reeve, & Moon, 2012; Sparks et al., 2017). Autonomy-supportive behaviors include the provision of choice, offering meaningful rationales for activities, allowing for self-paced learning, and inviting questions and input from students (e.g., Assor, Kaplan, & Roth, 2002; Reeve & Jang, 2006; Van den Berghe, Vansteenkiste, Cardon, David Kirk, & Haerens, 2014). The provision of competence-support, or structure, is reflected in the use of clear and well-structured lesson plans, giving positive feedback, and varying tasks (e.g., Jang, Reeve, Ryan, & Kim, 2009; Niemiec & Ryan, 2009). Finally, relatedness-supportive, or interpersonally-involving environments, are characterized by teachers encouraging cooperation and teamwork, being friendly and caring toward students, empathizing with students, and prioritizing students' individual needs (e.g., Cox, Duncheon, & McDavid, 2009; Sparks, Dimmock, Lonsdale, & Jackson, 2016; Sun, Li, & Shen, 2017). There is an extensive body of

evidence—based on well-powered, randomized controlled intervention studies—to show that need supportive strategies can be trained and improved among PE teachers, and importantly, that those strategies also account for improvements in key student outcomes in PE, including physical activity participation and motivation (e.g., Lonsdale et al., 2013; Lonsdale et al., 2019; Lubans et al., 2017; Rosenkranz et al., 2012).

The literature on student-centered learning and need-supportive teaching have largely developed in isolation from one another. Considering these frameworks in conjunction, however, may not only provide an opportunity for theoretical integration, but may also offer important conceptual insight into the effects associated with student-centered learning interventions. Specifically, many of the principles that characterize student-centered learning strategies appear to also reflect the instructional practices that contribute to psychological need satisfaction. In student-centered learning interventions, for example, (a) responsibility for decision-making is placed in the hands of students (autonomy support), (b) trust is given to the students in terms of lesson planning (autonomy support, relatedness support), (c) students are encouraged to coach, work with, and instruct one another (autonomy support, competence support, and relatedness support), (d) students are encouraged to reflect on their own performance and find their own solutions (autonomy support, competence support), (e) students often work in pairs and/or teams (relatedness support), and (f) an individualized approach to learning is emphasized (autonomy support).

There is some evidence to support the notion that student-centered interventions may serve to satisfy students' psychological needs (and downstream motivational outcomes). According to Hellison (1998), for instance, student-centered learning strategies may be conductive to developing students' self-actualization and interpersonal skills. More recently, Smit, de Brabander, and Martens (2014) also examined high school student need satisfaction and motivation as a function of student-centered learning strategies. In this cross-sectional investigation, students who were working within student-centered learning environments were shown to report stronger perceptions of autonomy, competence, and relatedness need satisfaction, as well as greater enjoyment and effort. In addition, in one of the few intervention- and/or PE-related studies in which these issues have been examined, Wallhead and Ntoumanis (2004) provided students with an 8-session student-centered (SEPEP) program, and demonstrated that, relative to teacher-centered instruction, the SEPEP intervention may have been responsible for increased perceptions of autonomy, and in turn, improved motivational outcomes (see also, Alexander & Luckman, 2001; Gil-Arias, Harvey, Càrceles, Pràxedes, & Del Villar, 2017). In a separate investigation examining a student-centered intervention for physical activity among underserved youth (i.e., outside of PE), Wilson et al. (2005) contended that student-centered approaches may provide for need satisfaction (e.g., autonomy), and demonstrated improvements—relative to controls—on physical activity-related motivation and self-concept. Both of these intervention studies were conducted with relatively modest samples (of approximately 50 students), however, and so at present there is an absence of robust intervention-based evidence for the role of student-centered interventions in terms of students' motivation and need satisfaction.

Guided by recommendations for implementing student-centered learning (e.g., Land et al., 2012), we aimed to investigate the effects of a PE teacher training program targeting the use of student-centered learning strategies, relative to a typical-practice, teacher-centered teaching style control group. In light of the literature (and the outcomes associated with student-centered learning) reviewed above, we examined the effectiveness of the program in terms of students' perceptions of motivation, need satisfaction, effort, and their confidence in their ability to regulate their learning in PE (which we termed 'PE learning-efficacy'). For the purposes of sample size calculations and analyses, we considered students' autonomous (relative to controlled) motivation for PE as our primary outcome variable (i.e., by computing a relative autonomy index, or RAI, variable, which indicates the strength of students' autonomous relative to controlled motivation).[1] Our secondary outcome variables—namely autonomy, competence, and relatedness need satisfaction in PE, effort in PE, and PE learning-efficacy—were selected based on documented effects associated with teachers' student-centered and need-supportive behaviors (e.g., Aelterman et al., 2013; Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015; Smit et al., 2014), as well as recent work investigating the relations between teachers' need supportive behaviors and students' efficacy appraisals (e.g., Jackson et al, 2013). We first hypothesized that, relative to students in the control arm, those in the intervention arm would display more positive change over the intervention period in terms of their autonomous (relative to controlled) motivation for PE (cf. Wallhead & Ntoumanis, 2004; Wilson et al., 2005). We also hypothesized that, relative to those in the control arm, students in the intervention arm would report more positive change from pre-to-post intervention on secondary outcomes, namely, perceptions of autonomy, competence, and relatedness need satisfaction, self-reported effort in PE, and PE learning-efficacy (cf. Cornelius-White, 2007; Neumann, 2013; Smit et al., 2014).

1. Methods

1.1. Participants

Students were eligible to participate in the study if they were enrolled in a PE class at their school for the entire year and were aged between 12 and 16 years. For teachers to be eligible, recognized teaching credentials were required (preservice teachers were not eligible to participate). On the basis of α of 0.05 and 95% power to detect a significant differential change in the primary outcome variable (i.e., student RAI scores), and using an effect size of $d = 0.14$ (Sparks et al., 2017) with a clustering adjustment (Campbell, Elbourne, & Altman, 2004) based on a conservative anticipated intra-class correlation coefficient of 0.10 (Jaakkola, Wang, Yli-Piipari, & Liukkonen, 2015), a total sample size of 325 was needed. To protect against student attrition and preserve adequate statistical power, the sample size was inflated by 25%, meaning that a sample of at least 407 students was required. In total, baseline data were collected from 554 high school students (275 male, 279 female), aged 12–16 years ($M = 14.27$, $SD = 0.69$), who were recruited from rural and metropolitan schools in "blinded for review". Students were enrolled in 24 classes across 7 different Government, Independent, and Catholic high schools. Class sizes ranged from 14 to 27 and were drawn from grades 9 and 10. The average age of the 19 PE teachers included was 31.05 years ($SD = 9.12$, range = 23–54, 8 male, 11 female).

1.2. Procedure

Having received ethical approval from the authors' institutional review board (as well as from relevant educational authorities), principals of 30 Government, 30 Independent, and 10 Catholic high schools were informed about the study via email (and a follow-up phone call). If they were willing to allow their PE teachers to participate, principals were asked to share the details of the study with their relevant staff members, and to invite any interested teachers to notify the lead author. Seven principals (10%) expressed their interest and granted their PE teachers permission to be part of the study. In response, 19 teachers from seven different schools agreed to participate. Telephone meetings or in-person visits (with/by the lead author) subsequently took place in order to provide the teachers and PE departments with the relevant information about the study. All participating schools were randomly

[1] We do, however, also present separate analyses for each motivational regulation in our supplementary material (see Supplementary Material S1).

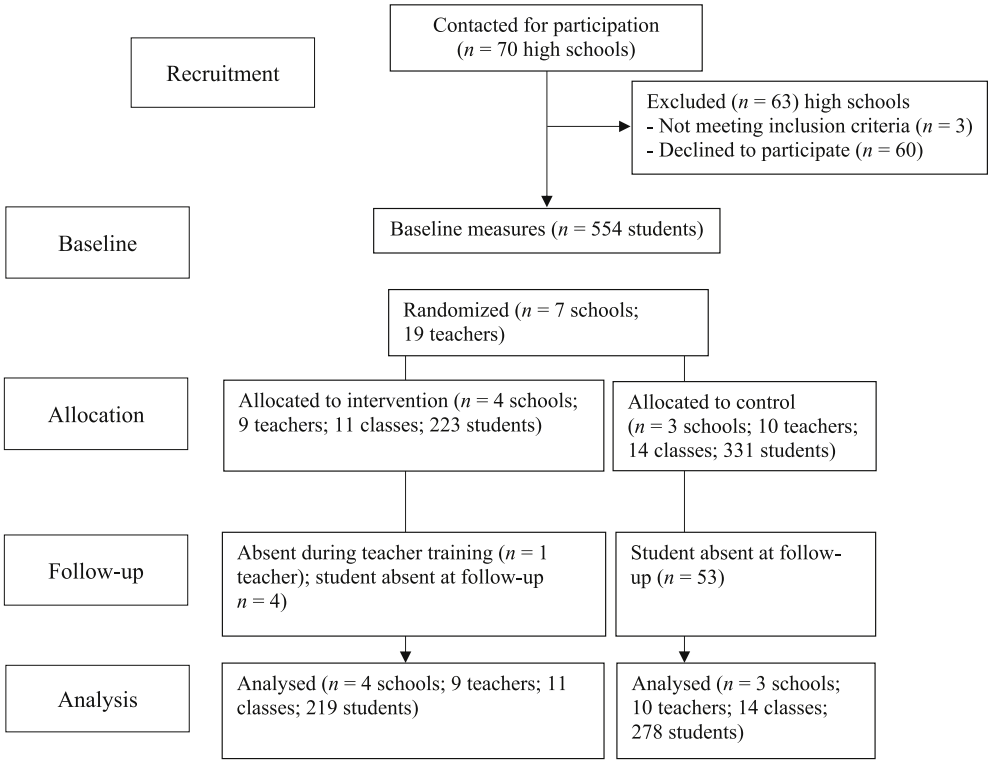

Fig. 1. Intervention flowchart (CONSORT). PE = physical education.

assigned by the lead researcher using a cluster-randomization method by simple random allocation (i.e., random-numbers table; Campbell et al., 2004) to either the intervention (4 schools, 9 teachers, 223 students) or the control arm (3 schools, 10 teachers, 331 students), see Figure 1. Randomization was conducted at the school level to decrease the risk of contamination (i.e., teachers informing other teachers about the training) and was performed after baseline measurements were completed. All participants were informed that participation was voluntary, that their responses would remain confidential at all times, and that students, teachers, and/or schools could withdraw from the study at any time. After obtaining informed consent from principals and teachers, parent/guardian information sheets were distributed; parents/guardians were informed of the nature of the study and provided with a prepaid return envelope should they wish to withdraw their child from the study before data collection.

Student data were collected at two time-points (i.e., pre-test and post-test; Figure 1 provides a schematic overview and timeline). Pre-test data were collected during term one or two in 2017 (according to availability and agreement of schools/teachers), and post-test data were collected 5 weeks after intervention start. All participating classes had a minimum of 2 h/week of physical education targeting invasion games (e.g., soccer, field hockey, netball), resulting in a minimum of 10 contact hours of the invasion game chosen. Following baseline assessment, teachers in the intervention arm participated in a 3-h training session (in their school at a time of their choosing) regarding the nature and implementation of student-centered learning (see following section for details), and were supported via regular email/telephone contact from the lead author during the five-week intervention period. Teachers in the intervention arm were encouraged to ask questions about the workshop and the implementation of the strategies at any stage during the intervention period. In comparison, teachers assigned to the control group were instructed to continue teaching in their usual manner, and were initially informed that the purpose of the work was to explore prospective (i.e., two time-point) relations between the variables under scrutiny. Control arm teachers were provided with the training workshop following the completion of all post-test assessments. For all (i.e., both intervention and control arm) teachers, an appointment was made for a research assistant—who was blinded to the nature of the study and group allocation—to visit schools and observe a class, with the purpose of coding teachers' use of student-centered learning strategies. All teacher observations took place during week three of the intervention, and teachers were not informed as to the true nature of the observation until all data collection had been completed.

1.3. Intervention description

A 3-h workshop was developed using a range of empirical evidence and guidelines relating to student-centered learning (e.g., Land et al., 2012; Smit et al., 2014; Wilson et al., 2005) workshop structure and activities were broadly consistent with recommendations for effective teacher training delivery (Aelterman et al., 2013). The workshop was delivered by the lead author, and to exemplify the notion of student-centered principles for participating teachers, the session was directed in a student-centered style. Specifically, participants were given the opportunity to shape discussion, and to reflect on and create their own strategies within a structured process (see Shepherd et al., 2012). The teacher workshop consisted of three parts: (a) theoretical background and introduction (approximately 45 min); (b) overview of student-centered learning (approximately 30 min theory, 30 min practice); and (c) active planning (i.e., participatory exercises) regarding the integration of these strategies into teachers' upcoming classes (approximately 45 min). Teacher feedback and questions were invited throughout the workshop.

Part one consisted of an introductory activity requiring group discussion, followed by coverage of the aims of the workshop, and an overview of the central principles underpinning student-centered learning. Before being introduced to the concept of student-centered learning, teachers were instructed as to the individual and class/group goals for the program. Initial coverage of student-centered learning was supported with research evidence to demonstrate the benefit of teachers as a 'learning facilitator' within PE, and the potential for student-centered strategies to realize beneficial student outcomes (e.g., Brandes &

Ginnis, 1996; Lubans et al., 2017; Onurkan & Özer, 2017). In the introductory section, the workshop facilitator also noted that teachers may have previously encountered these principles and learning strategies under other labels (e.g., discovery learning, peer teaching, self-reflection).

Part two of the workshop consisted of a more detailed overview of student-centered learning. Teachers were notified in detail of the practical methods associated with student-centered learning, including student involvement in decision making (i.e., what and how to learn), individualized learning (i.e., allowing time for, and facilitating, student reflection and analysis), the use of peer and group instruction and feedback, and providing students with responsibility for grouping and activities. Teachers viewed a short video outlining the broad tenets of student-centered learning (see Mae, 2015, youtube.com/watch?v = e6ieXLVCss4), and subsequently engaged in a group discussion regarding their previous experiences and implementation of this teaching style (including models such as SEPEP and TGfU). Teachers were encouraged to share any previous positive and negative experiences with this learning style. At this point, teachers were also briefly introduced to the notion of psychological need support. In addition to discussing the concepts of autonomy, competence, and relatedness support, teachers were given information about the motivational benefits associated with these instructional styles, and the ways through which student-centered learning methods may contribute to a need-supportive environment.

Subsequently, a short 'practice' session involving students was staged in order to demonstrate the student-centered learning style within a game situation. In the practice session, the sport of Ultimate Frisbee was used to illustrate learning principles, and the facilitator used guidelines outlined by Gréhaigne et al. (2001) regarding the structure of student-centered delivery. These guidelines, referred to as 'G – A – G', represent 'game – analysis – game'. Two teams (of approximately 4 students/team) were created, and minimal instructions were initially provided (i.e., solely relating to the goal of the activity), before teams were allowed to play for 5 min. Following this initial 'game' stage, 'analysis' involved illustrating various opportunities for teachers to encourage student-centered interactions. These opportunities included asking students to reflect on aspects of the game (e.g., "how did you like the game?"; "what went well?"), to make decisions about class/activity structure going forward (e.g., "what suggestions do you have to improve things?"), to encourage students to work together (e.g., "do you all agree that we should change things this way?"), and to give feedback and encouragement to one another. A second 'game' stage then followed for another 5–10 min, with intermittent opportunities for students to evaluate their changes, reassess, provide feedback (to the teacher and their peers), and look for improvements. Students who opted for a non-playing role (e.g., as instructors, observers, or coaches) were encouraged to observe and provide input, and to practice their own skills so as to improve their individual game performance. Throughout, the workshop facilitator adopted the role as a moderator of the learning process.

Part three of the workshop enabled participants to work together to discuss how they could feasibly integrate student-centered strategies into their teaching practices (and overcome anticipated challenges to those changes). This part of the workshop allowed for self-reflection and peer interaction, and was focused largely on creating both action (i.e., what, when, who, how issues) and coping (i.e., "what if", "if-then") plans for the implementation of student-centered approaches. With respect to identifying and overcoming potential challenges (e.g., an increase in 'talking time' at the expense of 'activity time', the integration of 'lazy' students, placing one's trust in students), the workshop facilitator provided some direction, but teachers were primarily encouraged to consider and devise practical approaches that they felt would be effective for introducing and practicing an invasion game (e.g., soccer, netball, field hockey), which was the specified activity format during the intervention period. Suggested methods included looking for ways to offer (reasonable) choice to students, emphasizing the responsibility associated with participation in decision making, identifying the value of reflective thinking and participation, highlighting the benefits of strengthening peer bonds, and reinforcing principles of honesty, hard work, trust, and respect (for the teacher and classmates). At the close of the workshop, teachers were made aware that they would receive (and could access) ongoing support from the lead author throughout the intervention period via phone or email. In addition, in instances when more than one teacher was participating from a given school, these teachers were encouraged to continue to support one another during the implementation of the intervention. Two weeks after attending the training workshop, all teachers were contacted by email to ask for their feedback, and to discuss solutions to any challenges that they may have faced during initial implementation of the program. The following week, the lead author again contacted all teachers to discuss progress relative to the prior (i.e., week 2) conversation.

1.4. Measures

1.4.1. Teachers' use of student-centered learning strategies

To assess teacher's use of student-centered instructional behaviors, a research assistant (who was blinded to the purpose and goals of the study) observed one entire class from each participating teacher during week three of the intervention (i.e., intervention and control group teachers). Teachers were instructed that the purpose of the observation was to assess students' motivation for PE. The observer followed a protocol designed for the purpose of this study that assessed the frequency of use of student-centered learning strategies. As well as responding to the items outlined below, the observer was encouraged to make notes throughout the class to provide evidence for her ratings. The observer rated teacher behavior using the common stem, "in this class …", and responded to 12 items on a 4-point scale anchored at 1 (*never observed*) and 4 (*observed all of the time*). Items included, "the teacher gives the students choice about how they do the tasks in PE", "the teacher listens to the students' ideas", "the teacher is always telling the students what to do (R)", "the teacher takes students' perspective", "the teacher uses questioning", "the teacher encourages students to think and ask questions", and, "the teacher encourages students to make decisions in the class". Scores derived from this observer-rated instrument demonstrated evidence of acceptable internal consistency ($\alpha = 0.95$).

1.4.2. Student motivation

Students' motivation for PE was measured using the Perceived Locus of Causality (PLOC) questionnaire (Goudas, Biddle, & Fox, 1994). The PLOC questionnaire contains five subscales, each consisting of four items. To enable temporal specificity within pre- and post-intervention assessments, we employed the stem, "at the moment, I take part in PE classes …", and presented items assessing intrinsic motivation (e.g., "… because it is fun"), identified regulation (e.g., "… because I want to learn sport skills"), introjected regulation (e.g., "… because it bothers me if I don't"), external regulation (e.g., "… because that's the rule"), and amotivation (e.g., "… but I can't see what I am getting out of PE"). All responses were made on a seven-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). The composite RAI, an established weighting formula based on students' mean scores for intrinsic motivation (+2), identified regulation (+1), introjected regulation (−1), and extrinsic regulation (−2), was computed to represent students' autonomous (relative to controlled) motivation for PE. Higher RAI scores represent stronger autonomous (relative to controlled) motivation. Previous PE-based research has demonstrated support for the validity and reliability of scores derived from the PLOC questionnaire and the computation of the RAI (e.g., Jackson et al., 2013; Lonsdale et al., 2011). In this study, alpha coefficients computed for pre- and post-test scores derived from each subscale were as follows: intrinsic motivation

α = 0.91/.89; identified regulation α = 0.88/.89; introjected regulation α = 0.75/.75; extrinsic regulation α = 0.81/.78; amotivation α = 0.82/.81.

1.4.3. Basic psychological need satisfaction

Students were asked to report their basic psychological need satisfaction in PE using a 15-item instrument. Perceptions of autonomy need satisfaction were measured using five items employed by Standage, Duda, and Ntoumanis (2006), following the stem "At the moment, when I am in this PE class …" (e.g., "I feel a certain freedom in choosing what I do"). Competence need satisfaction was measured using five items from the perceived competence subscale in the Intrinsic Motivation Inventory (IMI; Ryan, 1982; e.g., "I think I am pretty good at PE"). Finally, relatedness need satisfaction was measured using a contextually modified version of the five-item acceptance subscale (e.g., "I feel like a valued member of the class") from the perceived relatedness scale (Richer & Vallerand, 1998). All responses were made on a seven-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Scores derived from these measures have demonstrated evidence of internal consistency in previous PE-based studies (e.g., Standage et al., 2006; Taylor, Ntoumanis, Standage, & Spray, 2010), and alpha coefficients in the present study for pre- and post-intervention scores were as follows: autonomy, α = 0.77/.77; competence, α = 0.85/.82; relatedness, α = 0.92/.90.

1.4.4. Effort

The five-item effort-importance subscale of the IMI (Ryan, 1982) was used to measure students' perceptions of effort in PE. Responses to items (e.g., "I put a lot of effort into PE") were scored on a seven-point scale anchored at 1 (*strongly disagree*) and 7 (*strongly agree*). Support for the validity and reliability of scores derived from this subscale has been reported previously (e.g., McAuley, Duncan, & Tammen, 1989), and the alpha coefficients derived for scores on pre- and post-intervention assessments were 0.80 and 0.75, respectively.

1.4.5. PE learning-efficacy

Students' PE learning-efficacy was assessed using an instrument developed specifically for this investigation. Given that we were also assessing students' perceived competence need satisfaction, this instrument was not designed to measure students' confidence in performing the physical activities and skills within PE (e.g., being skilled at the activities and movements involved in PE). Rather, this instrument was designed to assess the skills associated specifically with performing student-centered learning activities (e.g., to plan learning activities, work with peers, monitor progress). The eight-item instrument was presented to students using the stem, "Please honestly rate your confidence in your ability at this moment in time to …. ", and consistent with recent PE-based efficacy assessments (e.g., Jackson, Whipp, Chua, Pengelley, & Beauchamp, 2012), students rated their PE learning-efficacy perceptions on a scale ranging from 1 (*no confidence at all*) to 5 (*complete confidence*). Example items included, "plan activities that suit your needs and ability", and "work together to create ideas and activities in PE". For a full list of items, along with item-level descriptive statistics, see Supplementary Materials (Table S2). The alpha coefficients for pre- and post-intervention scores derived from this instrument were both 0.92.

1.5. Data analysis

1.5.1. Data screening

Descriptive statistics were computed using IBM SPSS version 24 (IBM Inc., Chicago, IL). We initially screened for missing data and normality, and examined univariate (i.e., standardized scores, $|z| > 3.30$) and multivariate outliers (i.e., Mahalanobis distance at $p < .001$; Tabachnick & Fidell, 2011). Missing data (comprising 2.5% of the original data file) were replaced using the expectation-maximization method (see Graham, 2009). First, we conducted a three-way (2 × 2 x 2) between-groups MANOVA with all primary baseline scores as dependent variables, and group assignment, completer status (i.e., completers vs. dropouts), and gender as independent factors. This MANOVA was performed to (a) establish whether randomization was successful, (b) determine whether differences existed on baseline variables between students who completed both pre- and post-test measures (i.e., completers) and those who completed only pre-test measures (i.e., dropouts), and (c) identify any gender differences on baseline variables. Subsequently, to examine intervention fidelity, we conducted an independent-samples *t*-test to determine between-condition (i.e., treatment vs. control) differences on teachers' use of student-centered learning behaviors (i.e., observer rating scores).

1.5.2. Main analysis

To examine condition-by-time effects on students' motivation (primary outcome), and need satisfaction, effort, and PE learning-efficacy (secondary outcomes), and in light of the hierarchical structure of the data (i.e., students nested in classes), we conducted a series of linear mixed models using IBM SPSS version 24. We modeled the fixed effects of treatment condition (intervention vs. control) and time (pre-test vs. post-test), random effects of class, and a condition-by-time interaction. We calculated effect size for the condition-by-time effect using methods proposed by Morris (2008), which are based on mean pre-to-post-test changes in the treatment group minus the mean pre-to-post-test changes in the control group, divided by the pooled pre-test standard deviation. Values of 0.2 (small), 0.5 (moderate), and 0.8 (large) were used when interpreting effect sizes (Cohen, 1992). For the analyses described in the main manuscript, a per-protocol approach was used. Specifically, we analyzed data only from students who provided both baseline *and* follow-up data ($n = 497$). Four students from the intervention group, and 53 students from the control arm were absent at the follow up (i.e., 90% retention rate; see Figure 1). The per-protocol approach was selected because our primary goal was to determine the effect of the teacher training on students who received the 'treatment' (Ten Have et al., 2008). In line with recommendations, however, we also performed the same analyses using an intention-to-treat approach, in which all students who provided baseline data were retained (regardless of their participation in post-intervention assessment). Using the "last observation carried forward" approach, we carried forward baseline scores for those who did not provide post-intervention data in the intention-to-treat analysis (i.e., assuming no change over time). The results from the intention-to-treat analyses can be found in the Supplementary Material (Table S3).

2. Results

2.1. Descriptive statistics and data screening

Descriptive data for pre- and post-intervention assessments are presented for students in each condition in Table 1. The three-way MANOVA examining potential differences on baseline scores revealed nonsignificant multivariate main effects for condition, $F(6, 541) = 1.51$, $p = .17$, $\lambda = 0.98$, completer vs. dropout status, $F(6, 541) = 1.69$, $p = .12$, $\lambda = 0.98$, and gender, $F(6, 541) = 1.33$, $p = .24$, $\lambda = 0.98$, as well as no significant multivariate two-way or three-way interactions. The independent-samples *t*-test to assess fidelity (using observer ratings) revealed that teachers in the intervention group ($M = 2.57$, $SD = 0.46$) implemented student-centered learning strategies with significantly greater frequency, $t(17) = 9.05$, $p < .001$, $d = 4.04$, than those in the control group ($M = 1.23$, $SD = 0.09$).

2.2. Main analysis

Table 1 displays the results of the linear mixed models for students' autonomous relative to controlled motivation (RAI), perceptions of

Table 1
Mean scores and changes in student variables from pretest to posttest.

Measure	Pre-test		Post-test		Δ Change		Condition* Time	
	M	*SE*	*M*	*SE*	*M*	*SE*	*p*	*d*
RAI								
Intervention	3.55	.40	3.40	.40	-.15	.33	.005*	0.11
Control	2.96	.35	2.15	.35	-.81	.27		
Autonomy								
Intervention	4.12	.08	4.55	.08	+.44	.08	.001**	0.30
Control	4.05	.07	4.03	.07	-.02	.06		
Competence								
Intervention	4.45	.09	4.60	.09	+.14	.08	.241	0.08
Control	4.59	.08	4.61	.08	+.03	.06		
Relatedness								
Intervention	4.19	.10	4.53	.10	+.33	.09	.001**	0.22
Control	4.54	.09	4.53	.09	-.01	.06		
Effort								
Intervention	4.80	.09	4.84	.09	+.05	.09	.015*	0.30
Control	4.80	.08	4.58	.08	-.20	.07		
PE learning-eff								
Intervention	3.21	.06	3.60	.06	+.34	.06	.001**	0.41
Control	3.40	.05	3.36	.05	-.03	.04		

Note. Δ Change = posttest mean – pretest mean; RAI = relative autonomy index (intrinsic motivation x 2) + (identified motivation x 1) + (introjected regulation x −1) + (external regulation x −2); PE learning-eff = students' PE learning-efficacy; *d* = effect size.
*$p < .05$. **$p < .01$.

autonomy, competence, and relatedness need satisfaction, effort, and PE learning-efficacy. Regarding our primary outcome—students' RAI scores—a significant condition-by-time interaction was observed, $F(3, 525) = 4.27$, $p = .005$, $d = 0.11$. Separate one-way ANOVAs assessing change over time in each condition showed a significant decrease for autonomous (relative to controlled) motivation for students in the control arm, $F(1, 277) = 8.85$, $p = .003$, $d = 0.14$, but no change for those in the intervention arm, $F(1, 218) = 0.20$, $p = .65$, $d = 0.03$. A significant condition-by-time interaction emerged for students' autonomy need satisfaction, $F(3, 551) = 13.63$, $p = .001$, $d = 0.30$; students in the intervention arm displayed a significant increase in autonomy satisfaction across the intervention period, $F(1, 218) = 28.00$, $p = .001$, $d = 0.36$, but there was no change for control arm students, $F(1, 277) = 0.203$, $p = .65$, $d = 0.03$. We also observed a significant condition-by-time interaction for relatedness satisfaction, $F(3, 528) = 6.02$, $p = .001$, $d = 0.22$; relatedness satisfaction significantly increased for students in the intervention arm, $F(1, 218) = 12.93$, $p = .001$, $d = 0.22$, but did not change for those in the control arm, $F(1, 277) = 0.02$, $p = .89$, $d = 0.01$. No significant interaction effect was observed for students' competence satisfaction, $F(3, 534) = 1.40$, $p = .24$, $d = 0.08$, alongside no significant main effects for condition, $F(1, 497) = 0.525$, $p = .47$, or time, $F(1, 494) = 2.72$, $p = .10$.

A significant condition-by-time interaction was found for students' perceptions of effort in PE, $F(3, 557) = 3.54$, $p = .015$, $d = 0.30$. Follow-up one-way ANOVAs showed that effort did not change significantly for those in the intervention arm, $F(1, 218) = 0.31$, $p = .58$, $d = 0.04$, but decreased significantly for those in the control arm, $F(1, 277) = 7.87$, $p = .005$, $d = 0.17$. A significant condition-by-time interaction was also observed for PE learning-efficacy, $F(3, 538) = 17.37$, $p = .001$, $d = 0.41$, such that there was a significant increase in confidence over-time for students' confidence within the intervention arm, $F(1, 218) = 33.68$, $p = .001$, $d = 0.38$, but no change for those in the control arm, $F(1, 277) = 0.51$, $p = .48$, $d = 0.03$. In the Supplementary Material (see "S3: Intention to Treat Analyses"), the same analyses are reported using the intention-to-treat protocol; substantive conclusions from this alternative method were identical to those reported above.

Separate (per-protocol) analyses for each of the motivational regulations are provided in the Supplementary Material ("S1: Motivational Regulations"). Briefly, analyses for individual motivational regulations revealed that the control arm students displayed a decrease over time in intrinsic motivation and identified regulation, alongside an increase in amotivation. For students in the treatment arm, however, these analyses revealed evidence of maintained intrinsic motivation over time, increases in identified (and, interestingly, introjected) regulation, and no change in amotivation. Statistical output to support these conclusions is presented in the Supplementary Material. For the interested reader, bivariate correlations among all baseline variables for students in the intervention and control arms at pre- and post-intervention are available in the Supplementary Materials (Table S4 & S5).

3. Discussion

Despite conceptual similarities between student-centered teaching and (SDT-based) need supportive teaching, researchers often discuss and investigate these pedagogical methods in isolation from one another. With a view to theoretical and pedagogical integration, we sought to understand the effects of student-centered methods through the lens of SDT. Specifically, our primary aim was to investigate the effects of a PE teacher training program focused on the use of student-centered learning on students' motivation for PE. A secondary aim was to explore the influence of the PE teacher training program on PE students' need satisfaction, effort, and confidence in their ability to regulate their learning (i.e., PE learning-efficacy). After establishing that our randomization procedure was effective (i.e., that there were no baseline between-condition differences on key variables), that no baseline differences existed between males and females or completers and dropouts, and demonstrating support for the fidelity of the training program (i.e., using observer ratings of teacher behavior), we found general support for our main hypotheses. In support of our first hypothesis, students of teachers in the intervention arm, relative to those whose teachers were in a typical-practice control condition, displayed more positive change in motivation (i.e., autonomous forms of motivation) for PE across the intervention. In relation to—and in support of—our second hypothesis, students in the treatment arm (relative to those in the control arm) also displayed more positive change across the intervention on autonomy and relatedness need satisfaction, effort, and PE learning-efficacy.

SDT posits that high quality (i.e., autonomous) motivation catalyzes a range of desirable performance-, persistence-, and affect-related outcomes (e.g., Deci & Ryan, 2000), and as such, significant research attention has been directed toward identifying methods suited for promoting these forms of motivation among students. There has, however, been a relative absence of intervention-based insight into the role of student-centered teaching as a method for encouraging positive change on autonomous motivation. In this investigation, we observed that students who took part in student-centered PE classes displayed more positive change over time on autonomous (relative to controlled) motivation, when compared to those who took part in typical, teacher-directed classes. Interestingly though, the time-by-condition interaction for motivation (and self-reported effort in PE) was not characterized, as was anticipated, by increases in treatment arm students' motivation or effort (relative to no change for controls). Rather, we observed decreased motivation (and effort) for control students, and *maintained* (i.e., statistically unchanged) motivation and effort for those students in the intervention arm.

The nature of these interaction effects for motivation and effort was perhaps somewhat unexpected, particularly when considering that we did observe the expected interaction pattern for students' PE-learning efficacy, autonomy need satisfaction, and relatedness need satisfaction (i.e., no change over time for control arm students, significant over-time increases for intervention arm students). These interaction effects for PE-learning efficacy, autonomy need satisfaction, and relatedness need satisfaction offer some insight into the potential mechanisms through which student-centered learning strategies may engender the beneficial effects observed in previous studies (e.g., Goodyear & Dudley, 2015;

Land et al., 2012; Metzler, 2011). In addition, these effects for autonomy and relatedness need satisfaction demonstrate support for our contentions that the characteristics of student-centered learning (e.g., encouraging student decision-making, providing choice, inviting questions and critical thinking, encouraging teamwork and peer coaching) might satisfy SDT-based needs among students. These effects may not, however, fully explain the fact that we observed maintenance, rather than improvement, on (treatment arm) students' motivation and effort across the program. The fact that students in the intervention arm displayed more positive change in motivation (and effort) remains noteworthy, and demonstrates an important effect for student-centered teaching strategies (compared to typical teacher-centered strategies). According to principles of SDT, however, we might have anticipated that by encouraging *increases* in autonomy and relatedness need satisfaction, as well as a form of confidence (or competence), we would also have stimulated *growth* (rather than maintenance) in motivation and effort. There may be several reasons for the observed effects; we recognize that any attempt to explain these effects is speculative and not data-driven (at least, with respect to *our* data), but below we offer potential interpretations for the pattern of effects that we observed.

First, it is possible that the increases we observed on autonomy, relatedness, and (a form of) confidence for students in the intervention arm may simply require greater time in order to translate into substantial motivational improvements. Our design included a 5-week interval between pre- and post-program assessments, and although the satisfaction of needs may have begun to improve students' general motivation for PE over this time period, a greater duration may be required in order to observe the full effects of these mechanistic changes (Lehtinen, Vauras, Salonen, Olkinuora, & Kinnunen, 1995; Smit et al., 2014). Accordingly, we acknowledge that it would have been particularly valuable had we collected a third wave of data (another 5 weeks, or school term, later), in order to examine longer term change in motivation and effort.

Second, it is also possible that there may be factors other than need satisfaction that typically, across the course of a term, tend to shape, or detract from, students' motivation and effort in PE (as we observed for the control group). That being the case, the stimulation of greater autonomy need satisfaction, relatedness need satisfaction, and PE-learning efficacy might simply have served to *protect* against any motivation deterioration for students in the face of these challenges. There is evidence to suggest, for example, that over the course of a typical term, factors such as increases in student fatigue (Jang, Kim, & Reeve, 2016), elevations in academic and assessment burden (Darby, Longmire-Avital, Chenault, & Haglund, 2013), and a lack of variety in class (Sylvester et al., 2014), might all feasibly contribute to a downward trend in desirable forms of motivation and effort (as we witnessed for students in the control arm). In support, our analyses of change in the individual motivational regulations revealed evidence of decreases in intrinsic motivation and identified regulation over time for students in the control arm, along with corresponding increases in amotivation. Interestingly, we also observed increases in introjected regulation among students in the treatment arm, which (given that introjection is typically weighted negatively in RAI calculation) would have compromised any 'positive' effects associated with increases in (what are often considered) more adaptive, positively-weighted regulations (e.g., identified regulation) within the treatment arm students. For debate on the extent to which introjected regulation is truly 'negative' in nature, however, readers are directed toward a recent meta-analytic examination of the continuum structure of motivation within SDT (Howard, Gagné, & Bureau, 2017).

Prior to considering design limitations and directions for future research, it is important to note the significant interaction that we observed for (the construct we referred to as) PE-learning efficacy. This agentic perception was characterized by students' beliefs regarding their planning, teamwork, instructive, and communication skills. Given that students in the intervention arm were provided with explicit opportunities to enact and practice these skills (which control arm students were not), it is not surprising that students in the student-centered learning condition reported greater confidence over time in these skills. It would be particularly interesting, however, to determine the extent to which the development of these beliefs within PE—through the use of student-centered learning strategies—may generalize to other contexts and support improvements in downstream self-regulatory, teamwork, and communication outcomes in other academic and non-academic pursuits. In discussing students' confidence perceptions, it is also important to highlight that we did not observe any improvements in competence need satisfaction for those in the intervention arm. That is, relative to 'typical' practice, the intervention did not encourage students to feel more capable with respect to performing the activities (i.e., movement skills, game play) within PE. Although our analyses indicate that student-centered teaching may encourage adaptive outcomes, the introduction of such methods is not without challenge (see Lee & Branch, 2017), and consideration is therefore needed to ensure that the use of this pedagogy does not compromise the development of students' athletic and physical skills (e.g., by integrating sufficient skill guidance and correction from teachers).

The strengths of this study include the controlled, cluster-randomized design, the focus on conceptual (SDT) and pedagogical (student-centered learning) integration, and the inclusion of observer assessments to determine intervention feasibility. Balanced against these strengths, however, are important design limitations that accompany a number of significant considerations for future research. First, we documented support for the effectiveness of the intervention using only self-report methods. Although these methods are most appropriate for the assessment of our focal primary and secondary outcomes, it would have been valuable to also incorporate third party observational data (e.g., teacher ratings of student effort) and/or behavioral outcomes (e.g., skill execution, in-class achievement and physical activity levels). Second, we examined only relatively short-term (5 week) intervention effects, and although we observed some support for feasibility and effectiveness of student-centered teaching across this time frame, we cannot make robust long-term claims regarding (a) the extent to which teachers are able to implement these strategies on an ongoing basis, or (b) the lasting student outcomes associated with this pedagogical approach. Third, a more comprehensive suite of fidelity assessments would be worthwhile in replications and extensions of this work; supplementary methods might include, for instance, obtaining teacher reflections and 'self-checks', and/or including more frequent external observation so as to provide an average teacher behavior score and desensitize teachers as to the presence of an observer. Fourth, although the cluster randomized controlled trial design provided robust evidence of the potential effectiveness of this approach, it is important that future work is conducted to examine in more detail the practicalities and feasibility of these teaching strategies in the longer-term; such work would be valuable for highlighting any barriers to this kind of teaching method, and identifying appropriate solutions. Finally, although we showed significant intervention effects for students' (autonomy and relatedness) need satisfaction, we were unable to determine the relative (and differential) need-supportive contributions made by teachers and classmates as a result of the student-centered approach. From a conceptual perspective, it would have been particularly interesting to isolate students' perceptions of teacher- and peer-derived need support alongside their (overall) need satisfaction in PE, so as to identify how student-centered learning strategies may encourage differential need-supportive behaviors from these key social agents.

There are well-established bodies of literature documenting the student outcomes that can be achieved through student-centered learning strategies and the satisfaction of students' basic psychological needs. These two literature have, however, developed largely in isolation of each other, and our aim in this investigation was not only to examine the motivational outcomes stemming from a student-centered

learning intervention, but also to better understand whether any desirable outcomes of such pedagogical approaches may be explained by the satisfaction of students' needs. Our analyses largely revealed support for our assertions, and demonstrated that student-centered methods may satisfy students' autonomy and relatedness needs, as well as promoting (or at least, protecting or maintaining) their motivation and effort in PE. We hope this investigation offers a foundation for further work that provides robust insight into the psychological process underpinning student-centered learning outcomes.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2019.101553.

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