

Testing the efficacy of need-supportive instruction on skill performance, Motivation, & Affect

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Published online: May 31, 2026

Accepted for publication: May 15, 2026

DOI:10.7752/jpes.2026.05105

Abstract

Motivation is widely regarded as a fundamental driving force underlying human behavior. Self-Determination Theory, one of the most prominent social-cognitive frameworks for understanding motivation, posits that all individuals possess three basic psychological needs—autonomy, relatedness, and competence—which are essential for optimal growth and well-being. Grounded in this theoretical framework, the present study aimed to examine the effectiveness of psychological need-supportive instruction (NSI) on motor skill performance, motivation, and affect. A sample of 110 participants ($M_{age} = 20.56 \pm 2.25$; 62.7% females) was randomly allocated to either an NSI or need-neglecting instruction (NNI) condition. Five 50-minute juggling lessons were taught by one instructor following a structured lesson format with two distinct and different instructional modalities serving as an independent variable. Dependent variables were juggling performance, self-determined motivation, enjoyment, and state anxiety, with trait anxiety, situational interest, and gender set as the covariates. The analysis of covariance showed a statistically significant between-group effect on skill performance ($F[2,106] = 4.15$, $p = .044$, $\eta^2 = .04$; NSI>NT), intrinsic motivation ($F[2,106] = 8.87$, $p = .004$, $\eta^2 = .08$, NSI>NNI), introjected regulation ($F[2,106] = 6.06$, $p = .012$, $\eta^2 = .06$, NSI<NNI), extrinsic regulation ($F[2,106] = 9.45$, $p = .003$, $\eta^2 = .08$, NSI<NNI), and amotivation ($F[2,106] = 12.29$, $p < .001$, $\eta^2 = .12$, NSI<NNI). Additionally, there was a significant between-group effect on enjoyment ($F[2,106] = 24.23$, $p < .001$, $\eta^2 = .19$, NSI>NNI) and state anxiety ($F[2,106] = -3.17$, $p = .020$, $\eta^2 = .05$, NSI>NNI). In conclusion, NSI was an effective instructional strategy when aiming to improve participants' motor skill performance, motivation, and positive affect.

Key Words: RCT, self-determination, intrinsic motivation, motor skills, state anxiety

Introduction

Motivation can be regarded as one of the driving forces in human behavior. Motivation is typically defined as the direction and intensity of one's effort (Sage, 1977). In physical activity (PA), motivation has found to relate to exercise and PA adoption (e.g., participation) (Gagne 2003; Vallerand, 1997), engagement (e.g., PA intensity) (Cheon et al., 2012; Lonsdale, Sabiston, Raedeke, Ha, & Sum, 2009; Ntoumanis, 2005; Reeve et al., 2004; Tessier et al., 2010), adherence (positive affective response) (Ryan et al., 1997; Teixeira et al., 2012), and performance (Cerasoli, Nicklin, & Ford, 2014; Charbonneau, Barling, & Kelloway, 2001; Manninen, Deng, Hwang, Waller, & Yli-Piipari, 2022a). Although the positive benefits of quantity and quality motivation have been found to relate to these positive PA outcomes and human functioning, one of the central questions about human performance is how we can better nurture human motivation to harness these aforementioned positive consequences (Deci & Ryan, 2000; Ryan & Deci, 2017).

Self-Determination Theory (SDT) is one of the most prominent social-cognitive theories examining human motivation, performance, and well-being (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017). According to the SDT, the universal three basic psychological needs (needs for autonomy [a sense of being the initiator of one's behavior], relatedness [a sense of connected and belonging to others], and competence [feelings of capability and mastering one's goals and outcomes]) are essential for human growth and well-being (Deci & Ryan, 1985, 2000). It is theorized that when these three basic psychological needs are satisfied, it contributes to individuals' psychological growth, autonomous motivation, and well-being are nurtured (Deci & Ryan, 2000).

SDT acknowledges not only the quantity of motivation but also the quality of human motivation (Deci & Ryan, 2000). Based on the SDT framework, humans' motivation ranges along the continuum of controlled to autonomous (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017). At one end of the continuum, there is intrinsic motivation, which is a fully autonomous state. When intrinsically motivated, individuals engage in activities for the pleasure and inherent satisfaction derived from the participation. At the middle of the continuum are located the three levels of extrinsic motivation: integrated regulation (i.e., behaviors that are performed within an individual's goals and values), identified regulation (i.e., behaviors that are performed as valuable and essential

to an individual), and introjected regulation (i.e., behaviors that are performed to achieve others' approval or avoid internal pressures and feeling guilty). The fourth, most extrinsic form of extrinsic motivation is extrinsic regulation, which refers to activities performed for external reasons, e.g. reward, wealth, grades, status, appearance, or avoiding negative consequences. Finally, at the far end of the continuum of autonomy is amotivation, which can be defined as a total lack of motivation. Individuals with amotivation do not have any goal or purpose for engaging in activities, and they often experience feelings of incompetence (Deci & Ryan, 1985). SDT hypothesizes that the most autonomous (self-determined) motivations (intrinsic motivation, integrated regulation, and identified regulation) are adaptive motivations with positive affective, cognitive, and behavioral outcomes, whereas controlled (non-self-determined) motivations (introjected, extrinsic, and amotivation) are maladaptive with negative outcomes (Deci & Ryan, 1985; Vallerand, 1997). Centered around the SDT, NSI can be defined as an instruction that supports the three basic psychological needs of competence, autonomy, and relatedness as theorized by the SDT (Manninen et al., 2022a; Manninen & Yli-Piipari, 2021; Tessier et al., 2010).

Following the theoretical postulations of the SDT, NSI will positively influence nurturing self-determined motivation and impacting people's optimal development and well-being (Ryan & Deci, 2017). NNI or need-depriving instruction refers to the instruction that ignores the psychological needs of the participants (Manninen et al., 2022a). Need-thwarting instruction, on the other hand, represents a condition that do not meet participants' psychological needs (Bartholomew et al, 2011a, 2011b). Need-thwarting instructional practices can include the usage of extrinsic goals, controlling language, a lack of choice and ownership, a lack of dialogue relating to different ways to perform tasks, and rigidity towards participants' opinions and desires (Manninen et al., 2022a). SDT theorizes that need-thwarting psychological environment and instruction increases ill-being (Ryan & Deci 2017). It is logical to assume that instruction is not dichotomous nor trichotomous, but a fluid process including quality and quantity of motivational instructional ranging and actions, and ranging in the continuum from high need-support to need-thwarting.

Although a positive relationship between psychological need-satisfaction and behavioral, motivational, and affective outcomes is well established throughout numerous non-experimental studies (see meta-analyses Howard, Slep, & Wang, 2024; Lochbaum & Jean-Noel, 2015), there is a scarce body of experimental evidence testing the central assumption of the SDT. In regards to the experimental evidence, the study conducted by Manninen et al. (2022a), involving a sample of 59 college undergraduate students ($M=20.26 \pm 1.90$; 75% female), found that NSI to be superior compared to NNI in participants skill performance and adaptive motivation. The study used juggling and a novel motor skill, and the study showed that there was a statistically significant between-group effect on intrinsic motivation ($F[1, 49] = 5.52, p < .023, \eta^2 = .10$) and skill performance ($F[1, 48] = 9.23, p = .004, \eta^2 = 0.16$). In addition, study findings demonstrated that participants in the NSI group enjoyed participation more than participants in the NNI group ($F[1, 49] = 4.89, p = .032, \eta^2 = .09$). However, there were no statistically significant group-level differences in participants' state anxiety. Similarly, there is empirical evidence derived from two non-experimental meta-analytic reviews in educational (Howard et al., 2024) and sport, PA, and physical education contexts (Lochbaum & Jean-Noel, 2015) have showed that need-supportive instruction correlates positively with students' psychological outcomes, and the correlation with need-thwarting instruction and negative outcomes have shown to display either opposite relationship (Howard et al., 2024) or no relationship at all (Lochbaum & Jean-Noel, 2015). In relation to empirical evidence in enjoyment, NNI in the sport, PA, and physical education contexts has shown to improve participants' enjoyment (Edmunds et al., 2008; Manninen et al., 2022a; Mouratidis et al., 2011). On the other hand, need-thwarting instruction has been found to be associated with maladaptive outcomes, such as disordered eating, depression, burnout, negative affect, and physical symptoms, as well as elevated levels of secretory immunoglobulin A (Bartholomew et al., 2011b). Also, need-thwarting instruction in the PA context has been shown to predict higher state anxiety (Quested et al., 2011), sport anxiety (Haraldsen et al., 2020), and somatic anxiety (Papaioannou & Kolli, 1999).

Although there is early evidence that has shown the positive relationship between NNI and participants' behavioral, motivational, and affective outcome, more evidence is needed to validate previous experimental findings (Manninen et al., 2022a). The current evidence on NSI is largely correlational or derived from the quasi-experimental intervention research. One of the few rigorously conducted experimental studies, Manninen et al. (2022a), has shown NSI to be superior compared to NNI in improving participants skill performance, adaptive motivation, and enjoyment. However, their study did not detect any statistically significant differences in state anxiety (Manninen et al., 2022a).

Therefore, the aim of this study was to follow the study procedures of Manninen et al. (2022a) to examine the efficacy of NSI instruction on behavioral and motivational outcomes. It was hypothesized that participants who will receive NSI would report higher levels of participants' skill performance (Barkoukis et al., 2010; Manninen et al., 2022a; Valentini & Rudisill, 2004a; 2004b), self-determined motivation (Kirby et al., 2015; Manninen et al., 2022a; Vasconcellos et al., 2020), enjoyment (Edmunds et al., 2008; Manninen et al., 2022a; Mouratidis et al., 2011), and state anxiety (Quested et al., 2011) when compared to students receiving NNI. In terms of the skill performance, juggling was selected because it is a novel skill for most students, minimizing the effects of prior learning experiences on the study's outcomes

Materials & methods

Study design and participants

This study was a cluster randomized controlled trial located in the Southeastern United States. All participants were blinded to their intervention condition. A sample of 110 undergraduate college students ($M_{age} = 20.56 \pm 2.25$; 62.7% females; 45% white, 35% black, 8% Asian, 2% other) in four classes ($M_{size} = 27.5$) and enrolled in a university's basic physical education course agreed to participate in this study. Prior to gathering the data, participants completed the skill level test. Only subjects who did not have prior juggling skills were eligible to participate.

Procedures

This intervention replicated the study protocol of Manninen et al. (2022a), and it is explained below. All participants participated in the pre- and post-trial tests and intervention. A 36-year-old male instructor with six years of experience in teaching physical education and sound comprehension of the SDT theory and NSI and NNI taught all 20 (5 lessons for each group) 50-minute lessons during a two-week period. This approach was deliberately chosen to control instructor-related variables. The intervention was conducted during the fall semester (met 3-times/week on Monday, Wednesday, Friday, Monday, & Wednesday). Each lesson followed the same structure and content with differences only in instructional delivery. First, the instructor led a standardized 10-minute warm-up, including static and dynamic stretching. After that, the instructor delivered a 25-minute juggling skill-learning portion. During this portion of the lesson, the instructor introduced techniques for different types of 3-ball juggling skills from basics to advancing towards more complex ones. At the end of each lesson, the participants were provided 10 minutes of free practice time without the instructor's presence. At this time, the instructor and observers stayed outside the practice facility (not visible to the participants) to measure practice frequency. All participants were given three tennis balls and used the same balls for the entire length of the study. Pre- and post-trial tests included tests for the primary and secondary outcomes, and pretrial tests included additional tests for the theory-based covariates.

Experimental conditions

The NSI and NNI conditions followed the same dose, content, and structure. The teacher demonstrated same skills, offered same technical cues, and followed same minute-to-minute schedule as it related to the task progression (Manninen et al., 2022a; Van den Bergh et al., 2013). Each interaction with participants followed either NSI or -NNI strategy based on Table 1.

Table 1. Need supportive and -neglecting strategies

Need-Supportive Instruction Observation Scale		
Items	Rating	Items
1. Instructor provides tangible goals of the lesson and lays out reasonable expectations relating to participants' individual development and/or growth.	3 2 1 0 -1 -2 -3	1. Instructor provides inadequate goals and unrealistic or extrinsic (e.g., being better than others) expectations.
2. Instructor provides chances to choose drills at an optimal skill level.	3 2 1 0 -1 -2 -3	2. Instructor provides same tasks for everyone at the same time and rejects any differentiation or pressures participants to participate her/his way.
3. Instructor offers participants a rationale and expected learning outcomes for tasks and exercises.	3 2 1 0 -1 -2 -3	3. Instructor pushes participants to perform tasks without explaining why they should do what the instructor asks them to do. Instructor ignores participants' efforts to understand the tasks.
4. Instructor provides positive and informational feedback that signifies competence or improves competence.	3 2 1 0 -1 -2 -3	4. Instructor makes all decisions, provides simple tasks requiring lower level of cognitive engagement, and no time to work independently. Instructor provides no opportunities for participant ownership.
5. Instructor provides meaningful choice within the skill drills and flexibility with appropriate techniques.	3 2 1 0 -1 -2 -3	5. Instructor forces participants to follow instructor's decision and offers no choice.
6. Instructor provides new guidelines, tips and advice for participants leading to more engagement and higher-level learning.	3 2 1 0 -1 -2 -3	6. Instructor ignores chances to provide guidance, tips, or advice.
7. Instructor encourages participants to persist (e.g., "come on, you can do it").	3 2 1 0 -1 -2 -3	7. Instructor does not put any effort and energy into the lesson.
8. Instructor is close to the participants, moves around, and interacts with participants.	3 2 1 0 -1 -2 -3	8. Instructor does not move around the space and physically distances (her)himself from the participants.
9. Instructor asks participants questions about their interests, problems, values, or wishes addressing them by their first name.	3 2 1 0 -1 -2 -3	9. Instructor detaches from the participants and ignores their opinions or questions (acting cold).

NSI condition

The instruction was the independent variable of the study. NSI focused on nurturing the psychological needs of the participants based on the instructional strategies introduced in Table 1. E.g., the instructor provided participants chances to choose tasks at their optimal skill level and asked participants questions about their interests, problems, values, or wishes addressing them by their first name.

NNI condition

NNI, on the other hand, was planned to intentionally neglect participants' psychological needs. E.g., the instructor provided same tasks for everyone at the same time and required participants to participate her/his way and did not build any rapport with the participants and ignored their opinions. [Table 1 near here]

Measures**Primary outcomes**

Juggling skill performance. To assess skill performance, traditional three-ball juggling tests were used. Without warm-up and juggling skill practice to control the condition same for everyone, participants performed the basic cascade juggling skill twice in the 1x1m designated area. The trial was done when a participant dropped the ball, rotated the ball in a wrong pattern, or moved out of the designated area. After two trials, an average score was coded as a subtest score.

Exercise motivation. To measure participants' motivation in juggling, the Behavioral Regulations Questionnaire-3 (Markland & Tobin, 2004; Wilson, Rodgers, Loitz, & Scime, 2006) was used. The scale was developed to measure exercise motivation, but we revised exercise statements to focus on learning juggling skills. The participants answered the following stems: "I am going to take part in the basic PE course and its juggling module because (pretrial)" / "Thinking about the five last lessons of the course (juggling), I have taken part in this PE course because (posttrial)." Twenty-four statements reflecting the participants' intrinsic motivation integrated, identified, introjected, and extrinsic regulation and amotivation were included in the questionnaire. Intrinsic motivation (e.g., "because it's fun"), integrated regulation (e.g., "because it is consistent with my life goals"), identified regulation (e.g., "it's important to me"), introjected regulation (e.g., "I feel guilty when I don't"), extrinsic regulation (e.g., "because other people say I should"), and amotivation (e.g., "I don't see why I should have to participate) represent the different motivational regulations of the scale. The participants completed all items using a 7-point Likert-scale ranging from 1 (very untrue for me) to 7 (very true for me). The factorial validity and the scale's internal consistency have been found to be acceptable (Markland & Tobin, 2004).

Secondary outcomes

Enjoyment. The Physical Activity Enjoyment Scale (Kendzierski & DeCarlo, 1991) was used to assess the participants' enjoyment assuming a unidimensional structure of enjoyment that was developed for college students. The participants answered 18 items using a 7-point bipolar Likert scale after reading the statement "How do you think you are going to feel about the juggling classes you are going to have in the next two weeks (pretest)" / "how do you feel about the juggling classes you have been doing for the past two weeks (posttest)." Examples of the items include "It is not at all stimulating/it is very stimulating" and "I feel bored/I feel interested." The scale has demonstrated good internal consistency, test-retest reliability, and criterion validity among this population (Kendzierski & Carlo, 1991).

State anxiety. To assess the participants' levels of state anxiety toward the juggling lessons, an adapted 20-item version of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used. The scale contains self-report measures for state (e.g., "I feel nervous") anxiety. The participants were asked to rate their levels of anxiety using a 7-point Likert-scale (1 = very untrue for me; 7 very true for me). Examples of items include "Indicate how you feel at the moment about the upcoming juggling classes (pretest)" / "Indicate how you feel at the moment about the upcoming lessons of the course (posttest)." The scale has been found to have good concurrent and discriminant validity (Spielberger et al., 1983) as well as good internal consistency (Barnes, Harp, & Jung, 2002).

Exploratory outcome

In-class free-choice practice time. A modified version of the systematic observation method SOPLAY (System of Observing Play and Leisure Activity in Youth; McKenzie, Marshall, Sallis, & Conway, 2000) was used to observe participants' juggling practice time during the three randomly selected pre-meditated free-choice practice sessions (same lesson for each condition). To record participants' own practice, the SOPLAY utilizes momentary time sampling. Three observers independently conducted five concurrent scans of the participants' behavior (practicing/not practicing) during the 10 minutes (every two minutes intervals) free-choice period. The interrater reliability was measured with an intra-class correlation (ICC [2,3]; two-way random effect; absolute agreement) over twelve observations. The rate of the participants' practice was calculated as two combined percentages (one for each condition) of active participants over the twelve observed lessons (six for each condition and three for each group).

Out-of-class practice time. Participants' daily juggling practice outside of class was measured using a self-reported log. This log requested details on the amount of time spent practicing juggling each day from the initial pre-test up to the final post-test. Logs were submitted at the end of the study period.

Covariates

Trait anxiety. An adapted version of the trait anxiety section of the State-Trait Anxiety Inventory (Spielberger et al., 1983) was used to assess students' trait anxiety levels. The inventory includes 20-items (e.g., "I feel nervous and restless") representing the level of participants' trait anxiety. Participants will be rated themselves using a 7-point Likert-scale (1 = never; 7 = always) after reading the following stem: "Indicate how you generally feel." The scale has been found to have a good validity (Spielberger & Sydeman, 1994) and reliability (Barnes et al., 2002).

Situational interest. The Situational Interest Scale (Chen, Darst, & Pangrazi, 1999) was used to assess participants' interest in juggling. The scale consists of five subscales with four items each rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Examples of items include: novelty (e.g., 'what I did today was new to me'); instant enjoyment (e.g., 'what I did was enjoyable for me'); exploration intention (e.g., 'I wanted to analyze and have a better handle on what I was learning today'); attention demand (e.g., 'what I was learning demanded my high attention'); and challenge (e.g., 'what I was learning was hard for me to do'). For the between-group analyses, a composite situational interest variable was created by calculating an aggregated mean using all five subdimensions. The scale has been shown to be internally consistent and to have good validity using confirmatory factor analysis (Chen et al., 1999).

Fidelity measure

Instructor adherence. To assess instructor's adherence to NSI and NNI instructional strategies, NSTI scale was used (Hwang et al., in press). The NSTI observational scale consists of three need-supportive teaching dimensions of autonomy support (e.g., 'Instructor provides chances to choose drills at an optimal skill level'), relatedness support (e.g., 'Instructor is close to the participants, moves around, and interacts with participants'), and competence support (e.g., 'Instructor provides positive and informational feedback that signifies competence or improves competence'). The NSTI observation scale was coded for five consecutive 25-minute classes using a 7-point frequency scale, ranging from 3 (need-supportive behavior observed three times) to -3 (need-thwarting behavior observed three times) by three trained raters (blinded to the conditions). Interrater reliability of the observation checklist over eight observed lessons was adequate (ICC [2,3]; two-way random effect model with absolute agreement; .71). Single scores for each of the ten behaviors were averaged together to create a score for each behavior for a single lesson for one observer. Given the adequate interrater reliability of the rating system, the aggregated scores from the two raters were further averaged together to create a score for each of the instructional behaviors and strategies for the analyses.

Perceived need-support. The Perceived Environmental Supportiveness Scale (Markland & Tobin, 2010) was used to assess participants' perceived need-support. The scale comprises of 15 items with five items evaluating each of the three dimensions of need-support. The participants were asked to rate the items after the following stem "My teacher will... (pretest). Based on the five last lessons of the course (juggling), my teacher... (post-test)." Examples of the items include "make me feel like I matter to him (involvement), "take into account my individual needs" (autonomy-support), and "help me feel confident" (structure). The items were rated on a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree). The scale has been shown to be valid and internally consistent (Markland & Tobin, 2010).

Randomization

Four classes were randomized to two conditions using a free resource research randomizer program (www.randomizer.org).

Sample size

Statistical power was calculated for the repeated measures analysis of variance using G*Power 3.1.2. We conservatively estimated a moderate effect size (.25) (within-subjects). Using an alpha of .05, an estimated correlation of $r = .50$, we expected that a sample of 34 participants was required for the 80% power. To account for the data clustering, 34 were adjusted by design effect (Kish, 1965) of $1 + (m-1) \times ICC$, where m is the sample size of each cluster (25 participants per group), and ICC is an intraclass coefficient. ICCs were determined based on the findings of Yli-Piipari et al. (2018), who found class level ICC of motivational regulations to be below .05. The final correcting equation was used: $1 + (25-1) \times .05 = 2.20$. Thus, the total minimum sample was $1.70 \times 34 = 75$.

Statistical analyses

First, we completed preliminary analyses, e.g., Cronbach alphas for the internal consistency of the measured constructs and 2-way random effect with the absolute agreement ICC (2,3) for the interrater reliability on the instructional strategy observations. Group differences at the pretrial were tested with a one-way analysis of variance. To compare the effects of the experimental conditions on the exploratory outcomes of free-choice and out-of-class practice time, a one-way analysis of variance was conducted. To compare between-group effects on the outcome variables, an analysis of covariance was conducted with trait anxiety, situational interest, gender, and the pretest scores as covariates. Partial eta squared (η^2). All analyses performed using the SPSS (version 22) and Mplus (Version 7.1; Muthén & Muthén, 1998–2013). Alpha set at $p < .05$ for all tests. Standardized mean changes were calculated, with values of .2 (small), .5 (moderate), and .8 (large) used as guidelines for interpreting analyses of covariance effect sizes (Cohen, 1988).

Results

Preliminary analysis

Missing values and normal distribution of the scores

Preliminary analyses included cleaning of the data, scale reliabilities, and descriptive analyses, e.g., means, standard deviations (SD) were conducted and are presented in Table (2 and 3).

Table 2. Characteristics of the Participants

Variables	Experimental Group	Control Group
Age (SD)	21.0(2.83)	20.17(1.50)
Gender (%)		
Male	23 (39.7%)	18 (34.6%)
Female	35 (60.3%)	34 (65.4%)
Ethnic group (%)		
White Caucasian	40 (69%)	39 (75)
Black African American	5 (8.6%)	4 (7.7%)
Asian	10 (17.2%)	6 (11.5%)
Hispanic	3 (5.2%)	3 (5.8%)
Class rank (%)		
Freshman	9 (15.5%)	4 (7.7%)
Sophomore	12 (20.7%)	8 (15.4%)
Junior	14 (24.1%)	9 (17.3%)
Senior	23 (39.7%)	31 (59.6%)

Our preliminary analyses showed statistically significant differences between self-reported out-of-class daily practice time for each day between the pretrial and posttrial ($t(94) = 1.47, p = .027$), with the students in the NSI condition practicing more. Based on the in-class practice observations, on average 22.0% of the students in the NNI condition were practicing during the free-choice activity across five measurement points, whereas in the need-supportive condition the percentage was 37.4%.

Fidelity measures

Both the objective assessments and students' self-reports showed that the instructor was able to adhere to the pre-planned instructional strategy in both conditions. Observation analyses revealed that NSI (range across 5 lessons 2.05 to 2.88) lessons were different from NNI (range -1.89 to -1.42) lessons in terms of each dimensions of measured need-support (range from $t[108] = 92.23, p < .001$ to $t[108] = 40.38, p < .001$). In addition, compared to the students in the NNI condition, students in the NSI condition perceived that the instructor supported more their needs of autonomy ($F[2,107] = 12.74, p < .001, \eta^2 = .11$), relatedness ($F[2,107] = 2.49, p = .027, \eta^2 = .45$) and competence ($F[2,107] = 4.86, p = .030, \eta^2 = .43$) from the pre- to posttrial tests. However, there were no statistically significant difference in relatedness-support.

Aim 1

Analysis of covariance test results showed a significant between-group intervention effect on skill performance ($F[2,105] = 4.70, p = .032, \eta^2 = .05$), intrinsic motivation ($F[2,104] = 4.16, p = .044, \eta^2 = .04$), introjected regulation ($F[2,104] = 5.07, p = .026, \eta^2 = .05$), extrinsic regulation ($F[2,104] = 5.25, p = .021, \eta^2 = .05$), and amotivation ($F[2,104] = 10.69, p = .001, \eta^2 = .09$). In regards to the interaction between covariates and performance, our analyses showed gender to be the only statistically significant covariate ($F[2,105] = 15.39, p < .001, \eta^2 = .13.20$), with males having better performance compared to females. In terms of motivational regulations, there was a statistically significant interaction between gender and intrinsic motivation ($F[2,104] = 4.77, p = .031, \eta^2 = .04$; males having higher intrinsic motivation), situational interest and extrinsic regulation ($F[2,104] = 6.68, p = .011, \eta^2 = .06$; more interested participants had lower extrinsic regulation levels), and amotivation and situational interest ($F[2,104] = 17.85, p < .001, \eta^2 = .14$; low situational interest related to higher amotivation).

In addition, the analysis of covariance test results showed a significant between-group intervention effect on both enjoyment ($F[2,104] = 54.33, p < .001, \eta^2 = .34$) and state anxiety ($F[2,104] = 5.74, p = .018, \eta^2 = .05$), with NSI group having higher enjoyment and lower state anxiety compared to the NNI group. Regarding the covariate interactions, our analyses showed gender to be the only statistically significant covariate on enjoyment. ($F[2,104] = 4.77, p = .031, \eta^2 = .04$), with males higher enjoyment than females. In state anxiety, there were no statistically significant covariance interactions.

Discussion

The aim of this study is to examine the efficacy of SDT-centered NSI on participants' motor skill performance, self-determined motivation, enjoyment, and state anxiety. Specifically, we were interested in testing the theory-based hypothesis that NSI is, compared to NNI, expected to be more beneficial in terms of participants' psychomotor, motivational, and affective outcomes. This study replicated the study protocols of Manninen et al. (2022a) and to enhance our understanding of the potential benefits of NSI.

Our study showed that compared to the NNI classes, participants performed better when exposed to the NSI-centered juggling classes. Our results align with the findings of Manninen et al. (2022a) that have demonstrated NSI participants to have better skill performance than participants in NNI condition. These results also support the previous findings that have shown autonomy-supportive teaching strategies to improve motor skill performance of children, children with disabilities (Valentini & Rudisill, 2004a; 2004b), high school students (Barkoukis, et al., 2010; Vansteenkiste et al., 2004), and college students (Behzadnia et al., 2019). Second, the study findings showed that NSI was a superior strategy in motivating participants towards the juggling skill task. Specifically, the results showed that NSI was beneficial in improving participants' intrinsic motivation. This finding corroborated the previous research findings that have shown NSI to positively affects adaptive motivation when psychological needs are supported (Fransen, et al., 2018; Lochbaum & Jean-Noel, 2015; Manninen et al., 2022a, 2022b; Moustaka et al., 2012; Vasconcellos et al., 2020). On the other hand, we found that NSI was improving participants' quality of motivation by reducing participants' introjected regulation, extrinsic regulation, and amotivation. These findings are encouraging as introjected regulation, extrinsic regulation, and amotivation are theorized to be maladaptive regulations with empirical evidence suggesting that maladaptive regulations lead to less optimal outcomes, e.g., poorer performance, lack of adherence, and lower intrinsic motivation (Aelterman et al., 2012; Bartholomew et al., 2011b; Manninen et al., 2022a; Ryan & Deci 2017; Standage et al., 2003; Teixeira et al., 2012). It is noteworthy that our study did not find any statistically significant differences in integrated or identified regulation. Integrated and identified regulations have shown to important motivators relating to more frequent exercise engagement and physical activity participation (Edmunds et al., 2008; Teixeira et al., 2012). It may be that compared to a juggling task, exercise and physical activity elicit more value-based responses in participants. In other words, as a task, juggling may be less value provoking compared to exercise and physical activity, since the positive health impacts of exercise and physical activity are universally recognized.

Finally, the results of the study showed that compared to NNI, NSI was more advantageous in improving participants' enjoyment and reducing state anxiety. This finding is in line with the previous findings that have shown NSI to increase participant enjoyment (Edmunds et al., 2008; Manninen et al., 2022a; Mouratidis et al., 2011). These findings derived from rigorous experimental trials support the previous research that has shown psychological needs to relate positively to positive affect including enjoyment. Manninen et al. (2022a) showed that need-supportive instruction initiated a positive pathway in which need-support impacted intrinsic motivation (+), integrated regulation (+), and amotivation (-), which impacted enjoyment positively explaining almost 60% in enjoyment during the 12-week intervention. Interestingly and on the contrary to the findings of this study, the study by Manninen et al. (2022a) did not find any differences in state anxiety when comparing NSI and need-neglecting instruction.

Conclusions

The findings of this study inform future researchers and practitioners alike. First, the results of this study suggest that NSI is a beneficial instructional strategy to yield better skill performance, motivational outcomes, and less state anxiety. Although these results are promising, future experimental studies are needed in the broad area on PA. E.g., experimental studies examining instruction in sport are much in demand. It may be that athletes have different tolerance in regards to different instructional styles compared to the college physical education students. Second, our findings supported the central tenets of the SDT that NSI had more positive impact on participant performance and motivation. PE practitioners are highly encouraged to utilize NSI in their instruction for optimal outcomes.

This study is not free from limitations. First, we utilized college physical education classes for this experiment. Although our sample participated in physical education, college-aged students are distinctively different from the K-12 physical education students. Second, only one instructor taught all the lesson which have representative issue. Future studies should employ several teachers to examine a teacher variance when using NSI. Finally, and similar to the previous study (Manninen et al 2022a), we used juggling as the novel skill. The primary reason for this was two-fold. First, juggling is a simple, and it is relatively straight forward to measure student performance. Second, it is possible to recruit a sample where everybody starts with no skill mastery. Future studies should utilize other skills to gain cross-validity.

Declaration of generative AI and AI-assisted technologies in the writing process

No AI or AI-assisted technologies were used during the preparation of this work.

Conflict of interest None

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Appendix

Table 3. Descriptive statistics of the variables

Variables	Control Group					Experimental Group				
	<i>M</i>	<i>SD</i>	<i>KU</i>	<i>SK</i>	<i>α</i>	<i>M</i>	<i>SD</i>	<i>KU</i>	<i>SK</i>	<i>α</i>
<i>Primary Outcome Variables</i>										
Skill 1	0	na	na	na	na	0	na	na	na	na
Skill 2	5.90	9.78	1.39	1.65	na	10.81	11.175	8.26	2.43	na
Intrinsic 1	5.37	1.18	-.34	-.22	.83	5.07	.78	-.18	.14	.83
Intrinsic 2	5.44	1.14	1.14	-.80	.76	5.71	1.15	-.89	-.32	.76
Integrated 1	3.48	1.41	-.09	.43	.58	3.51	1.11	.17	.35	.58
Integrated 2	3.69	1.38	-.40	.13	.85	3.75	1.18	.27	.26	.85
Identified 1	4.75	.96	.43	-.23	.75	4.56	.98	-.44	.07	.75
Identified 2	4.75	.91	-.56	.09	.76	4.83	.89	-.22	.24	.76
Introjected 1	3.71	1.61	-1.07	.03	.65	3.62	1.37	-.49	.04	.75
Introjected 2	4.03	1.35	-.69	-.17	.82	3.59	1.31	-.34	-.17	.82
Extrinsic 1	2.86	1.33	.01	.61	.61	2.86	1.24	1.27	.68	.71
Extrinsic 2	3.20	1.39	-.21	.50	.93	2.77	1.10	-.16	.19	.93
Amotivation 1	2.000	.81	-.10	.70	.78	2.34	1.01	-.05	.55	.78
Amotivation 2	2.66	1.13	.97	.88	.82	2.22	1.00	-.83	.49	.82
<i>Secondary Outcome Variables</i>										
Enjoyment 1	3.78	.34	2.54	1.12	.96	3.72	.40	2.64	-1.62	.96
Enjoyment 2	3.33	.55	2.22	.88	.97	4.54	.57	-.20	.15	.97
State Anxiety 1	4.00	.59	1.59	-.41	.95	3.82	.44	2.08	-.62	.95
State Anxiety 2	4.07	.540	5.68	-1.68	.95	3.75	.65	4.55	-1.75	.95
<i>Covariates</i>										
Trait Anxiety 1	3.92	.34	-.20	.13	.93	3.97	.37	-.12	.28	.93
Situational Interest	5.30	1.26	1.25	-.61	.91	5.25	1.12	-.95	-.17	.93
Interest EI 1	5.23	1.27	.75	-.84	.83	4.87	1.14	-.70	.08	.83
Interest IE 1	5.09	1.45	.17	-.73	.77	4.94	1.12	-.39	-.04	.77
Interest N 1	5.31	1.03	-.75	-.10	.84	5.02	1.04	-.40	-.02	.84
Interest AD 1	5.47	1.07	1.69	-.81	.57	4.98	1.10	.00	-.26	.57
Interest C 1	5.16	1.07	.01	-.72	.62	5.00	1.03	.78	-.23	.62
<i>Fidelity Measure</i>										
Aut Support 1 Support	5.78	.86	-.63	-.40	.91	6.02	.84	-.47	-.51	.93
Aut Support 2	6.07	1.01	-.50	-.76	.92	5.67	1.07	-.65	-.43	.87
Com Support 1	5.94	.86	-.21	-.59	.94	6.05	.86	-.46	-.58	.94
Com Support 2	6.16	.98	.78	-1.17	.95	5.81	1.04	-.65	-.43	.90
Rel Support 1	5.74	.97	-.67	-.41	.96	5.85	.97	-1.01	-.35	.94
Rel Support 2	5.90	1.09	-1.24	-.47	.94	5.56	1.22	-1.02	-.29	.94