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ARTICLE

Integration of Information and Communication Technology and Pupils' Motivation in a Physical Education Setting

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The purpose of this study was to test an integrative model regarding the impact of information and communication technology (ICT) on achievement in physical education. Pupils' perceptions of autonomy-support from teacher, satisfaction of basic psychological needs, and self-determined motivation were considered to mediate the impact of ICT on pupils' cognitive skills and motor performance. Ninety-six pupils (44 boys and 52 girls; M_{age} = 12.40 years) were assigned to either the ICT or the traditional teaching (TT) condition of a quasi-experimental design. Results from path analyses supported the hypotheses that: (a) perception of autonomy support from teachers satisfies pupils' basic psychological needs; (b) basic needs satisfaction in turn leads to greater self-determined motivation, which (c) then contributes to the enhancement of cognitive skills and motor performance.

Keywords: Motor performance, cognitive skills, self-determination theory, psychological need satisfaction.

Research centered on the frequency of adolescents' physical activity has demonstrated that teenagers, especially boys, may prefer to be involved in technology-

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related activities rather than spending their free time on physical exercise (Allison et al., 2005). It should not therefore come as a surprise to learn that fitness professionals are showing an interest in building meaningful, structured digital technology environments to take advantage of pupils' propensity to use computers during their unstructured free time. One of their objectives is to incorporate Information and Communication Technology (ICT) into physical activity programs to motivate adolescents and young adults to become more physically active (NASPE, 2004; Trout, 2006).

Although ICT covers any product that will valuably store, retrieve, manipulate, transmit or receive information electronically in a digital form, the majority of physical education (PE) departments report a lack of training in using ICTs as well as how to deal with technical problems. Examining the barriers to the uptake of ICT by PE teachers, Thomas and Stratton (2006) underlined that "time was seen as the major barrier in using ICTs in PE, because the time needed to set up the equipment was limited" (p. 628). Due to the challenges in using ICTs, many teachers use traditional methods for transmitting information, such as, verbal explanations and demonstrations. Furthermore, to help pupils visualize content and remember what they have learned, PE teachers often provide them with brief written explanations and diagrams that depict the movement patterns to be carried out. However, these conventional teaching aids are of questionable relevance to the many dynamic movement parameters (i.e., displacement velocity and acceleration profiles) that have to be remembered and reproduced. Moreover, some PE teachers regularly question the value of handouts in terms of pupils' motivation (i.e., creating and maintaining a high level of pupil involvement in motor learning; Höffler & Leutner, 2007; Stratton & Finch, 2001).

New technology has come to be regarded as an integral part of sport practice today, with regard to monitoring physical effort (wristwatch/ heart rate monitor), correcting posture (image database) or elaborating collective strategies (interactive computer applications as spreadsheets) (Papastergiou, 2010; Russell & Newton, 2008). In this respect, for PE teachers, integrating ICT in PE lessons seems to be a new challenge to optimize potential motivational and behavioral benefits. Moreover, the examination of the literature suggests that the integration of ICT in PE may have an impact on pupils' motivation and, also may directly or indirectly—through motivation—influence performance.

Self-Determination Theory

Motivation with respect to academic learning—including learning in PE—can be fruitfully described through the lens of the Self-Determination Theory (SDT; Deci & Ryan, 2008). Self-determined motivation consists of freely engaging and persisting in an activity for the sake of pleasure that is experienced in this activity. Such an experience is fostered by the satisfaction of three psychological needs—namely autonomy, competence, and relatedness—that can be provided by social contexts such as the learning or the training context that is promoted by teachers or coaches (e.g., Legrain, Paquet, d'Arripe-Longueville, & Antonini Philippe, 2011; Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002; Zhang, Solmon, Kosma, Carson, & Gu, 2011).

The need for autonomy reflects the need for individuals to feel volitional and responsible for their own behavior (deCharms, 1968). An interpersonal context is said to be autonomy-supportive when teachers provide a meaningful rationale for performing the tasks, emphasizing choice rather than control, and acknowledging students' feelings and perspectives (Deci & Ryan, 1987). With regard to this need, Hennessy, Deaney, and Ruthven (2003) showed that ICT teaching conditions led teachers to support children's autonomy and were associated with an increase in students' self-regulation of learning.

The need for competence is the individual's inclination to interact effectively with the environment, the satisfaction of this need providing him or her with a feeling of efficacy (White, 1959). In PE settings, such a feeling was recently found to be promoted by an instructional approach that integrated multimedia blogging (Papastergiou, Gerodimos, & Antoniou, 2011).

The need for relatedness concerns the degree to which an individual feels connected and accepted by others (Baumeister & Leary, 1995). Regarding the relationships between this need and ITC, Smeets and Mooij (1999) showed that compared with traditional lessons, ICT lessons significantly increased social interactions between the teacher and pupils and among pupils during lessons.

Given the aforementioned implicit links between ICT and the satisfaction of the basic needs that foster self-determination, ICT may be regarded as a powerful instructional tool that may increase learners' motivation (Harp & Mayer, 1998; Passey, Rogers, Machell, & McHugh, 2004; Wang, 2008). However, to date, no study could be found that examined the effects of ICT in the PE domain on pupils' need satisfaction and self-determined motivation.

ICT in Academic and Sport Settings

ICT influences learning and performance both directly and indirectly, through the impact of motivation on performance. In academics, psychological needs satisfaction and self-determined motivation have been shown to be mechanisms that underlie the relationships between social factors and performance (e.g., Gillet, Vallerand, Amoura, & Baldes, 2010; Mouratidis, Vansteenkiste, Lens, & Sideridis, 2008). In the sport domain, because motor tasks mainly consist of mentally visualizing a process or a procedure to act, the visual animations embedded in ICT instructional tools can be considered as relevant means for execution (Elbourn & Cale, 2001; Wood, 2005) that can exert a direct influence on motor performance.

With regard to motor learning (Schmidt, 1988; Wulf & Shea, 2002), visual animations may help children's perceptions and actions to be more finely tuned as they progress through learning (Plumert, Kearney, Cremer, Recker, & Strutt, 2010). Especially in novices, the role of representation in learning may depend on whether the motion being depicted generates a mental model of the dynamics encompassing the movement itself, the trajectory, coordinated changes over time and changes in velocity (Bétrancourt & Tversky, 2000; Michas & Berry, 2000). Moreover, when the motor performance depends on a movement perception, as for morphocinetic skills, providing learners with data about the key characteristics of the skill to perform (e.g., pace, direction) enables them to integrate new information at their own pace, leading to representational and motor benefits (Beashel & Sibson, 2000).

Consequently, despite the few empirical research dedicated to the effects of new technology on the representational parameters of motor skill acquisition, both in youth sport and PE settings (Tearle, 2004; Tearle & Katene, 2005), motor benefits are expected from using key applications such as databases, presentation, graphics and web design software in the process of motor skill acquisition.

Based on the above-mentioned literature suggesting that ICT may influence self-determined motivation and learning in academic settings, the aim of the current study was to examine the influence of ICT integrated into PE lessons and pupils' perceptions of autonomy support from their teacher on their cognitive skills (i.e., knowledge relative to determining factors of the performance) and motor performance in gymnastics. Although previous studies evidenced direct positive relationships between instructional device and skills in academic (e.g., Bétrancourt & Tversky, 2000; Michas & Berry, 2000) and sport settings (e.g., Liebermann et al., 2002), no studies have yet examined the effect of the integration of ICT on motor performance in PE. We postulated that ICT integration would directly predict positive posttest motor performance and cognitive skills. The hypothesized model of relationships between the variables under study is depicted in Figure 1.

We hypothesized that, dummy coding the experimental conditions of ICT and traditional teaching (TT) in a structural model, ICT and pupils' perceptions of autonomy support would facilitate the satisfaction of basic psychological needs assessed in a posttest (e.g., Quested & Duda, 2011; Taylor & Lonsdale, 2010), after controlling for pretest psychological need satisfaction and motor performance. Drawing on both theoretical (e.g., Deci & Ryan, 2008) and empirical research (e.g., Gillet, Rosnet, & Vallerand, 2008; Tessier, Sarrazin, & Ntoumanis, 2010), we also hypothesized that pupils' satisfaction of basic needs at posttest would positively predict their self-determined motivation toward PE, which in turn would positively predict pupils' posttest motor performance (after controlling for pretest motor performance) and cognitive skills (e.g., Boiché, Sarrazin, Grouzet, Pelletier, & Chanal, 2008; Ratelle, Guay, Vallerand, Larose, & Senécal, 2007).

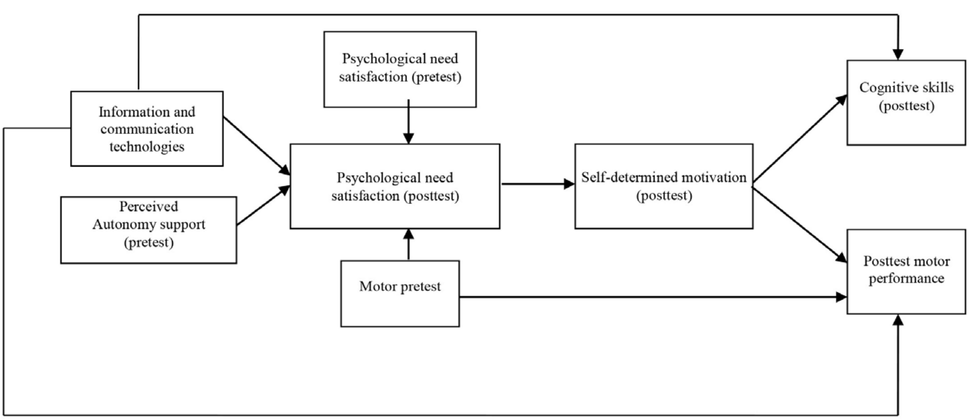

Figure 1 — Hypothesized Model

Method

Participants

Ninety-six adolescents from the same school in the Champagne-Ardenne region of France (44 boys and 52 girls; mean age = 12.40 years; *SD* = 0.55) volunteered to take part in the study. Pupils were predominantly white, and most were from a middle-class socioeconomic background. At the beginning of the experiment, participants had never encountered ICT in their PE lessons. They were randomly assigned to one of two instructional conditions (ICT *vs.* traditional teaching, TT).

Procedure

This quasi-experiment took place at the beginning of the academic year. The procedure included the following three phases: (a) pretest measurements, (b) six physical practice sessions, and (c) posttest measurements. After receiving a full explanation concerning the nature and purpose of the study, participants and families provided written consent before the study. The study was approved by the local ethics committee and was conducted in accordance with ethical guidelines (Harriss & Atkinson, 2009).

Pretest Measurements. Because they had no prior experience in gymnastics, participants were pretested during a PE lesson by a PE teacher blind to the experiment on four motor tests (i.e., tone, coordination, upper limb explosive strength, and balance) at four different stations. At the first station, participants were asked to hold a candlestick position for two seconds, standing on the back of their shoulders with their feet pointing toward the ceiling and their arms flat on the floor (shoulder stand). At the second station, participants had to perform a single forward roll without using their hands to stand up. At the third station, participants were asked to perform a gymnastic back roll on low parallel bars from and to a standing position. At the fourth station, participants had to perform ten push-ups, lowering and raising their body in a prone position using their arms.

Before the motor tests, participants were asked to complete a questionnaire measuring their use of new technology in everyday life; to control the family IT environment. Participants also completed two other questionnaires measuring their psychological need satisfaction in PE (Gillet et al., 2008), and their perceptions of their teacher's autonomy-supportive behavior (Gillet, Vallerand, Paty, Gobancé, & Berjot, 2010).

Physical Practice Sessions. In accordance with the curriculum, the ICT and TT participants all received six two-hour gymnastics lessons in which they performed similar gymnastic exercises after a 20-min warm-up session. The same PE teacher who was trained to integrate ICT into the PE lessons taught all the lessons for both groups. The ICT and TT participants were split up into small groups of 4–5 participants and practiced exercises within a gymnastics circuit, spending 20 min at each station. This circuit comprised five fully equipped stations dedicated to floor, parallel bar, mini-trampoline, balance beam, and junior foam vaulting horse exercises. In line with the Year 5 PE curriculum, the PE lessons had two main educational goals: Learning to turn and learning to reverse.

In the ICT condition, participants practiced the PE situations within an ICT learning environment that comprised of two televisions with video cassette recorders, two camcorders, ten pocket computers for recording and reviewing their performances, and an interactive whiteboard connected to a computer running software developed by the ICT-PE team of the local education authority (http://www.ac-reims.fr/datice/eps/tice_eps/productions_acad/powerpoint_gym/powerpoint_gym.html). Implemented under Microsoft Windows 2000/XP, this software invited pupils to select an apparatus and a theme (turning, reversing) and then showed them which daily exercises to perform. For each apparatus, they could observe a same-age expert model demonstrating the required skills and read written instructions as to how to copy them. To detect classic movement mistakes, they also had access to a technical databank in which the expert model demonstrated four common errors, all on the same screen. Finally, depending on which error they had selected, participants could view video footage suggesting exercises designed to improve the movement.

In the TT condition, participants practiced the same PE situations within a more traditional instructional learning environment using diagrams and written instructions that described the daily exercises to perform for each theme and each piece of apparatus. Pupils were told to use colored sheets containing technical diagrams to detect four possible classic movement errors made by their fellow participants. Finally, they were provided with a handbook describing the same four common errors for each movement as in the ICT condition, alongside the exercises prescribed to correct these errors and improve the movements.

All participants were given three 15-min training sessions in using the tools placed at their disposal to help them practice the gymnastic exercises in small groups. Thus, the first three lessons began with instructions as to how to use the teaching tools with respect to considerations of realism, control, and collaboration (Bétrancourt, 2005; Mayer & Chandler, 2001). Participants were trained to: (a) search for information in the interactive whiteboard's databank versus the handbook, (b) record video sequences of classmates performing gymnastics exercises versus use the worksheets to identify performance errors; and (c) develop a conception-matching process wherein the classmates' motor performance was compared with the demonstration by the same-age model.

Posttest Measurements. At the end of the sixth practice sequence and in accordance with the gymnastic curriculum, all of the participants were videotaped in specific situations. Participants were asked to perform a handstand forward roll and a cartwheel on the floor, a handstand on the balance beam, a dive roll on the mini trampoline, a handstand flat back on the foam vaulting horse, and a half turn with rear to front support on the parallel bars. Before this motor posttest, participants completed the Perceived Autonomy Support Scale for Sport Settings (Gillet, Vallerand, Paty, et al., 2010), the Basic Psychological Needs in Sport Scale (Gillet et al., 2008), and the Physical Education Motivation Scale (Tessier et al., 2010). Finally, participants' cognitive skills were assessed by means of a technical test in a separate and fitted-out room.

Measures

Use of New Technology in Everyday Life. According to the OECD Program for International Student Assessment (PISA, OECD 2006) survey, we asked the participants to indicate on a scale ranging from 0 (Never) to 4 (Always) how much they used ten different electronic devices (i.e., computer, camcorder, CD recorder, mobile phone, MP3 player) in their everyday lives. Participants' responses thus resulted in a score out of 40. Whereas questions of PISA 2006 survey indiscriminately addressed student's computer use at specific (home, school) and nonspecific (other places) locations, by using the phrase "everyday life", we did not address any specific location, according to other research (e.g., Selwyn, Gorard, Furlong, & Madden, 2003; Silverstone, 1996). By doing so, we ensured that any possible location of ICTs use was included without being prominently mentioned.

Motor Performance. Participants' motor performance was videotaped and independently assessed by two judges who were familiar with gymnastics skills and blind to the purpose of the study and experimental conditions. The judges practiced using the scoring scheme (i.e., not performed = 0 point, performed with two imperfections = 1 point, performed with a single error = 2 points, well performed = 3 points) by watching pilot videotapes of 10 same-age pupils performing the gymnastics exercises featured in William's (1997) gymnastics curriculum. The raters created four different scales for the pretest (i.e., tone, coordination, upper limb explosive strength, and balance), and five scales for the posttest (i.e., floor, balance beam, mini-trampoline, vaulting horse, and parallel bars). The judges clarified any discrepant coding before rating the experimental videotapes for subsequent data analysis. For the pilot videotapes, rater agreement ranged from 92% to 98%. Interrater reliability for motor performance judgments on the pretest and posttest was assessed by calculating the percentage of agreement between the two judges. These analyses yielded a high percentage of agreement ranging from 91.62% to 97.75%, and good intraclass correlation coefficients ranging from $r = .74$ to $r = .88$. Therefore, the judges' motor performance ratings were averaged.

Perceived Autonomy Support. The Perceived Autonomy Support Scale for Sport Settings (Gillet, Vallerand, Paty, et al., 2010), adapted to the PE context, was used to assess pupils' perceptions of the autonomy support they received from their teacher ($\alpha = .93$; e.g., "I feel that my PE teacher provides me with choices, options, and opportunities regarding how to do this sport activity"). Answers were given on a 7-point scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*). Previous research found this scale to have acceptable convergent validity, temporal stability, and internal consistency reliability ($\alpha = .91$; e.g., Gillet, Vallerand, Amoura, et al., 2010; Gillet, Vallerand, Paty, et al., 2010).

Psychological Needs Satisfaction. Satisfaction of the needs for competence (5 items, $\alpha = .93$; e.g., "In PE, I often feel very competent"), autonomy (5 items, $\alpha = .74$; e.g., "In PE, I have the opportunity to make decisions"), and relatedness (5 items, $\alpha = .85$; e.g., "In PE, I have a lot of sympathy for the other pupils") was measured using the Basic Psychological Needs in Sport Scale (Gillet et al., 2008) adapted to the PE context. Gillet et al. (2008) reported adequate factorial validity for the questionnaire as well as good internal consistencies for its subscales ($\alpha = .72$; $\alpha = .80$; and $\alpha = .83$, respectively). Pupils were asked to rate how true each of the statements was on a scale ranging from 1 (*Not at all true*) to 7 (*Completely true*). Given the quite small sample size and to reduce the number of variables in the tested model, an overall index of need fulfillment which aggregates scores across the three needs ($\alpha = .88$) was used according to Gillet, Fouquereau, Forest, Brunault, and Colombat (2012; see also Gillet, Colombat, Michinov, Pronost, & Fouquereau, 2013; Smith, Ntoumanis, Duda, & Vansteenkiste, 2011).

Self-Determined Motivation in PE. Pupils completed the Physical Education Motivation Scale (see Tessier et al., 2010). This tool is a 22-item inventory that assesses intrinsic motivation ($\alpha = .85$), identified regulation ($\alpha = .81$), introjected regulation ($\alpha = .80$), external regulation ($\alpha = .88$), and amotivation ($\alpha = .89$). Each item follows the stem "Why do you engage in PE lessons?", and responses are given on a 7-point scale ranging from 1 (*Never*) to 7 (*Always*). To reduce the number of parameters in our hypothesized model, the different subscales were combined into a composite index of self-determined motivation ($\alpha = .83$; e.g., Grolnick & Ryan, 1987; Ryan & Connell, 1989). This index reflects the extent to which pupils' motivation is more or less self-determined. It was created by summing each intrinsic motivation item multiplied by +2, each identified regulation item by +1, each introjected and external regulations item by -1, and each amotivation item by -2. Thus, higher scores on this index reflect a more self-determined motivation. Previous validation efforts have shown this scale to provide scores with acceptable reliability ($\alpha = .90$ for intrinsic motivation toward stimulation, $\alpha = .88$ for intrinsic motivation toward knowledge and accomplishment, $\alpha = .84$ for identified regulation, $\alpha = .69$ for introjected regulation, $\alpha = .67$ for external regulation, and $\alpha = .78$ for amotivation; e.g., Boiché et al., 2008).

Cognitive Skills. Participants' cognitive skills were assessed by means of a technical test asking pupils to observe a videotape of five floor exercises they had performed during the physical practice sessions. The five gymnastics exercises (i.e., scale, jump full turn, forward roll, backward roll, and cartwheel) were modeled by a same-age and same-sex model. For each exercise (presented twice), participants were asked to note down any execution errors they had spotted and suggest technical corrections in a two-column format. The video was made by two gymnastics experts, who identified four main behavioral errors for each exercise and put forward four technical suggestions for correcting them. Participants' responses were coded in comparison with those of the experts and scored out of a total of 40 points, with one point allocated for each error detected and one point for each relevant suggested correction.

Analyses

Preliminary Analyses. One-way ANOVAs (Group: ICT vs. TT) were computed to verify that the two groups did not differ as regards the criteria used to select the participants (see Table 1). No significant differences between the two groups were found on: (a) scores at the motor pretest, $F(1, 94) = 3.13$, $p = .08$, $\eta^2 = .03$); (b) gymnastics experience at their former schools and outside school, $F(1, 94) = 1.93$, $p = .17$, $\eta^2 = .02$, and (c) use of new technology in everyday life, $F(1, 94) = 1.63$, $p = .20$, $\eta^2 = .02$. As a result of these preliminary analyses, the two groups were not significantly different with respect to the dependent variables measured at the start of the experiment. Moreover, the effect sizes were small. Consequently, at the beginning of the study, the two groups were considered equivalent with respect to motor skill, gymnastics experience, and previous use of technology.

Table 1 Means (and Standard Deviations) for Participants' Motor Pretest, Gymnastic Experience and Use of New Technology at Home (N = 96)

	Information and Communication Technology (ICT) (n = 48)	Traditional Teaching (TT) (n = 48)
Motor pretest	1.73 (0.75)	1.45 (0.81)
Gymnastic experience	2.22 (1.05)	1.93 (1.00)
Use of new technology in everyday life	22.73 (6.50)	20.92 (7.37)

The means, standard deviations, and correlations across the study variables are set out in Table 2. Pupils' posttest need satisfaction was moderately and positively correlated with ICT, teacher's autonomy support, pretest need satisfaction, pretest motor performance, and self-determined motivation. Cognitive skills were moderately and positively correlated with ICT and self-determined motivation. Finally, posttest motor performance was moderately and positively correlated with ICT, self-determined motivation, and pretest motor performance.

Main Analyses. Due to the relatively small sample size, the proposed model was specified as a path analysis, using the robust maximum likelihood method with EQS 6.1 (Bentler, 1993). It contained four exogenous variables (i.e., the experimental condition, teacher's autonomy support, pretest basic need satisfaction, and pretest motor performance) and four endogenous variables (i.e., posttest basic need satisfaction, self-determined motivation, cognitive skills, and posttest motor performance). We applied the incremental fit index (IFI) and the comparative fit index (CFI) as incremental fit indexes, and the root mean square error of approximation (RMSEA) represented an absolute fit index. According to Hu and Bentler (1999), satisfactory fit of a hypothesized model to the data are indicated when the IFI and CFI are close to .95, and the RMSEA is close to .06. We also calculated the Satorra-Bentler χ^2 (S-B χ^2) and used the chi-square/df ratio (values lower than 2 indicate an adequate fit, Byrne, 1989) to determine model fit.

Results

Model fit indices revealed that the proposed model fit the data well: S-B χ^2 (df = 12, N = 96) = 14.38, p = .28; χ^2/df = 1.21; IFI = .98; CFI = .99; RMSEA = .05. However, as shown in Figure 2, the pathway between pretest and posttest need satisfaction was not significant (γ = .18), nor was the pathway between the experimental condition and posttest motor performance (γ = .11). Experimental condition (γ = .19), teacher's autonomy support (γ = .24), and pretest motor performance (γ = .42) were positive predictors of posttest need satisfaction. We also found a positive relationship between posttest need satisfaction and self-determined motivation (β = .49). In turn, self-determined motivation was significantly and positively related to posttest motor performance (β = .16) after controlling for the influence of pretest motor performance (γ = .61). Finally, cognitive skills were significantly and

Table 2 Means, Standard Deviations, and Correlations Among Variables

Variables	M	*SD*	1.	2.	3.	4.	5.	6.	7.	8.
1. Information and Communication Technologies	0.00	1.00	-							
2. Perceived autonomy support	5.26	0.95	-.14	-						
3. Pretest need satisfaction	4.80	1.02	.10	.51***	-					
4. Posttest need satisfaction	4.75	0.99	.25*	.28**	.48***	-				
5. Self-determined motivation	10.87	12.96	.16	.16	.42***	.49***	-			
6. Motor pretest	1.59	0.79	.18	-.05	.39***	.51***	.36***	-		
7. Posttest motor performance	0.94	0.66	.25*	-.06	.29**	.36***	.39***	.68***	-	
8. Cognitive skills	7.79	4.04	.41***	-.01	.33**	.23*	.39***	.29**	.24*	-

Note 1. * $p < .05$, ** $p < .01$, *** $p < .001$

Note 2. For the dummy coding variable, the experimental conditions were coded +1 for new information and communication technologies and -1 for control

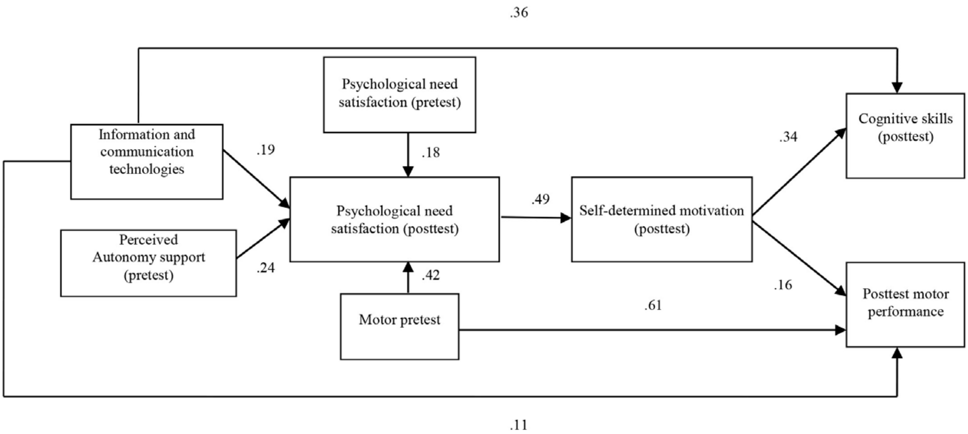

Figure 2 — Results from the Path Analysis. *Note 1.* All coefficients were standardized. *Note 2.* All relationships are significant ($p < .05$) with the exception of that between the experimental condition and posttest performance as well as that between pretest and posttest need satisfaction.

positively predicted by experimental condition ($\gamma = .36$) and by self-determined motivation ($\beta = .34$)[1].

Next we tested two alternative models. In the first one, experimental condition predicted teacher's autonomy support. Then, autonomy support predicted satisfaction of psychological needs at posttest controlling for pretest need satisfaction and motor performance. Finally, need satisfaction at posttest predicted self-determined motivation, which in turn predicted pupils' posttest motor performance (after controlling for pretest motor performance) and cognitive skills. In the second one, experimental condition and autonomy support predicted pupils' posttest motor performance (after controlling for pretest motor performance) and cognitive skills. Then, posttest motor performance and cognitive skills predicted need satisfaction at posttest controlling for pretest need satisfaction. Finally, need satisfaction at posttest predicted self-determined motivation. Results revealed that these two alternative models exhibited a worse fit than the hypothesized model (e.g., CFI = .81 and .82 for the first and second alternative models, respectively). The hypothesized model was thus judged the most plausible model on the basis of both theoretical and empirical grounds.

Discussion

The purpose of the current study was to test a model examining how ICT integrated into PE lessons as well as pupils' perceptions of autonomy support from their teacher may influence pupils' cognitive skills and performance in gymnastics, directly and indirectly through the mediation of basic psychological needs satisfaction and self-determined motivation. Results from structural equation modeling analyses supported our model. These findings have a number of implications.

First, results revealed that perceptions of autonomy support were positively associated with basic need satisfaction, which in turn predicted contextual self-determined motivation. In other words, the more pupils' basic psychological needs were satisfied, the more their motivation toward PE was self-determined. These results are consistent with previous research in education showing that psychological need satisfaction mediates the relationship between autonomy support and self-determined motivation (e.g., Amorose & Anderson-Butcher, 2007; Lavigne, Vallerand, & Miquelon, 2007).

Second, results revealed that ICT integrated into PE lessons was positively associated with posttest need satisfaction. These results parallel recent research findings which reported that students involved in an ICT physical activity program showed greater interest in the courses and displayed more attention, found the activity more attractive (Höffler & Leutner, 2007; Stratton & Finch, 2001), and demonstrated a higher level of motivation for maximizing peer interactions (Papastergiou et al., 2011). These results show that for pupils aged 12–13, an ICT environment leads to higher psychological need satisfaction, specifically when they perceive the learning process is conducted by a perceived autonomy-supportive teacher during gymnastics lessons.

Third, our results showed that self-determined motivation positively predicted pupils' cognitive skills and gymnastics performance. This finding is in line with our hypotheses and also with recent research on the role of self-determined motivation in the prediction of performances in educational (e.g., Boiché et al., 2008; Ratelle et al., 2007) and sport settings (e.g., Gillet, Vallerand, Amoura, et al., 2010). More generally, the present results also provided support for self-determination theory postulates and many other investigations in PE which have shown that self-determined motivation predicts positive consequences such as increased effort, physical activity intention, and positive affect (e.g., Taylor, Ntoumanis, Standage, & Spray, 2010; for a review, see Ntoumanis, 2012). Particularly, this finding contributes significantly to the comprehension of the ICT value in educational contexts and specifically in PE. Insofar as adolescents are more likely to display motivated behavior according to the pedagogical environment, pupils considered camcorders, pocket computers and computer running software connected to an interactive whiteboard as useful to provide valuable information in recording and reviewing their performances in PE. In particular, the more ICT provides pupils with the opportunity to improve their analytical skills and performance and to work constructively together, the more pupils would perceive ICT as an operational tool helping them to become independent learners (Beashel & Sibson, 2000). Such a learning environment would combine a form of extrinsic motivation with a form of intrinsic motivation to use the pedagogical tools placed at their disposal.

Finally, although ICT use positively and directly predicted cognitive skills, this learning condition did not directly predict the gymnastics performance. Cognitive benefits are consistent with motor learning theory whereby considerable knowledge is acquired by novices at the first step of learning, when cognitive processes are regarded as predominant (Schmidt, 1988). Furthermore, this finding emphasizes that ICT is beneficial for conveying knowledge about dynamic movements. This would encourage PE teachers to use ICT to help pupils build a mental model of what they have to perform. The augmented information that is conveyed by ICT provides pupils with a valuable guide that helps them be aware of performance criteria and meet these criteria to reinforce correct performance (Schmidt, 1988; Tearle & Katene, 2005; Wulf & Shea, 2002). However, in comparison with traditional instructional learning environment, ICT would not directly favor immediate motor benefits in movement execution.

Concerning this direct influence of ICT, the difference between cognitive and motor benefits may be due to the participants' developmental immaturity (von Hofsten & Fazel-Zandy, 1984) in selective attention, retention and control processes, and lack of experience affecting their ability to translate their perceptions into actions (Plumert et al., 2010). Additional research is needed to examine older and more experienced participants' psychological and motor responses in an ICT learning environment.

The results of the current study are inconsistent with prior findings indicating that ICT in a PE setting leads to significant gains in motivation (ICT self-efficacy) but not to significant gains in basketball knowledge (Papastergiou et al., 2011). Nevertheless, this inconsistency can be partly attributed to differences between the design of the current study and the one used by Papastergiou et al. (2011). In Papastergiou et al.'s study, the ICT course was not incorporated into the basketball practice as taught on the court. Therefore, these authors attributed their results to a lack of contextualization. Moreover, differences between basketball and gymnastics must be discussed with regard to closed and open motor skills involved in the performance.

There were several limitations to our study. First, the small sample size means that caution needs to be exercised in drawing conclusions, and the potential for ICT to have a meaningful impact on motivational changes may be restricted to the closed skills involved in gymnastics performance. Further research may be warranted with a larger sample and a sport environment in which open skills are required (Wulf & Shea, 2002). A second limitation concerns the lack of a control group. A third one pertains to the lack of qualitative data on the participants' use of the teaching tools to interact with each other. Future research should examine the participants' verbal and nonverbal interactions in small groups in relation to the amount of time spent on guidance tools (e.g., worksheets, video footage, handbook, interactive whiteboard) and the amount of time spent practicing (e.g., d'Arripe-Longueville, Gernigon, Huet, Cadopi, & Winnykamen, 2002). Fourth, measuring pupils' self-determined motivation at the pretest would have been useful to avoid an unbalanced model leading to bias. Indeed, the high path coefficient from posttest need satisfaction to posttest self-determined motivation could be due to the absence of control of self-determined motivation at the pretest, whereas the low path coefficient from posttest self-determined motivation to posttest motor performance could be due to the control of motor performance at the pretest. Furthermore, cognitive skills were only assessed through a technical test on floor exercises, which were deemed to be most familiar to them given their level of gymnastic proficiency. To narrow the gap between the physical and cognitive tests, a more refined cognitive test may be used in the future.

Although PE teachers are interested in motor learning outcomes achieved through new, innovative, or different delivery methods, ICT is still very much an untapped resource for enhancing young people's ability to participate in a wide range of sports and other movement-based activities. In line with previous research

(Russell, & Newton, 2008), the current study demonstrated that an ICT environment can foster pupils' motivation in a PE setting. The results suggest that the integration of ICT could be an interesting alternative strategy to enhance children's self-determined motivation for learning, and thus help them acquire new motor skills. Because questions have been raised about the contribution of PE programs not only to physical fitness, but also to the primary academic mission of schools (Russell & Newton, 2008), these results suggest that better preparing PE teachers to integrate ICT into lessons may benefit pupils.

Note

1. We also tested whether the hypothesized model adequately fit the data for each condition. Consequently, we tested model invariance by constraining all paths to be also equal across groups. Comparison of the CFI values between this model and the unconstrained model yielded a negligible difference, $\Delta CFI = -.02$, thus suggesting that the hypothesized model applied equally well to both groups. Similarly, mean intraclass correlation of all variables ($ICC = .11$) was relatively low. Overall, results suggest that, despite mean differences between groups, variance and covariance matrices are equivalent for both ICT and TT conditions.

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References

Allison, K.R., Dwyer, J.J., Goldenberg, E., Fein, A., Yoshida, K.K., & Boutilier, M. (2005). Male adolescents' reasons for participating in physical activity, barriers to participation and suggestions for increasing participation. *Adolescence, 40,* 155–170.

Amorose, A.J., & Anderson-Butcher, D. (2007). Autonomy-supportive coaching and self-determined motivation in high school and college athletes: A test of self-determination theory. *Psychology of Sport and Exercise, 8,* 654–670. doi:10.1016/j.psychsport.2006.11.003

Baumeister, R.F., & Leary, M.R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117,* 497–529. doi:10.1037/0033-2909.117.3.497

Beashel, P., & Sibson, A. (2000). ICT – help or hindrance? *British Journal of Teaching Physical Education, 31,* 6–8.

Bentler, P.M. (1993). *EQS Structural Equations Program Manual*. Los Angeles, CA: BMDP Statistical Software.

Bétrancourt, M. (2005). The animation and interactivity principles. In R.E. Mayer (Ed.), *Handbook of multimedia* (pp. 287–296). Cambridge, England: Cambridge University Press. doi:10.1017/CBO9780511816819.019

Bétrancourt, M., & Tversky, B. (2000). Effect of computer animation on users' performance: A review. *Le Travail Humain, 63,* 311–329.

Boiché, J.C.S., Sarrazin, P.G., Grouzet, F.M.E., Pelletier, L.G., & Chanal, J.P. (2008). Students' motivational profiles and achievement outcomes in physical education: A self-determination perspective. *Journal of Educational Psychology, 100,* 688–701. doi:10.1037/0022-0663.100.3.688

Byrne, B.M. (1989). *A primer of LISREL: Basic applications and programming for confirmatory factor analytic models*. New York: Springer-Verlag. doi:10.1007/978-1-4613-8885-2

deCharms, R.C. (1968). *Personal causation: The internal affective determinants of behavior*. New York, NY: Academic Press.

d'Arripe-Longueville, F., Gernigon, C., Huet, M-L., Cadopi, M., & Winnykamen, F. (2002). Peer tutoring in a physical education setting: Influence of tutor skill level on novice learners' motivation and performance. *Journal of Teaching in Physical Education, 22,* 105–123.

Deci, E.L., & Ryan, R.M. (1987). The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology, 53,* 1024–1037. doi:10.1037/0022-3514.53.6.1024

Deci, E.L., & Ryan, R.M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology, 49,* 14–23. doi:10.1037/0708-5591.49.1.14

Elbourn, J., & Cale, L. (2001). Selecting Computer-based resources to support learning in Physical Education. *The British Journal of Teaching Physical Education, 32*(4), 35–37.

Gillet, N., Colombat, P., Michinov, E., Pronost, A.M., & Fouquereau, E. (2013). Procedural justice, supervisor autonomy support, work satisfaction, organizational identification, and job performance: The mediating role of need satisfaction and perceived organizational support. *Journal of Advanced Nursing, 69,* 2560–2571.

Gillet, N., Fouquereau, E., Forest, J., Brunault, P., & Colombat, P. (2012). The impact of organizational factors on psychological needs and their relations with well-being. *Journal of Business and Psychology, 27,* 437–450. doi:10.1007/s10869-011-9253-2

Gillet, N., Rosnet, E., & Vallerand, R.J. (2008). Development of a scale to assess basic need satisfaction in the sport context. *Canadian Journal of Behavioural Science, 40,* 230–237. doi:10.1037/a0013201

Gillet, N., Vallerand, R.J., Amoura, S., & Baldes, B. (2010). Influence of coaches' autonomy support on athletes' motivation and sport performance: A test of the hierarchical model of intrinsic and extrinsic motivation. *Psychology of Sport and Exercise, 11,* 155–161. doi:10.1016/j.psychsport.2009.10.004

Gillet, N., Vallerand, R.J., Paty, E., Gobancé, L., & Berjot, S. (2010). French validation and adaptation of the Perceived Autonomy Support Scale for Exercise Settings to the sport context. *International Journal of Sport and Exercise Psychology, 8,* 118–128. doi:10.1080/1612197X.2010.9671937

Grolnick, W.S., & Ryan, R.M. (1987). Autonomy in children's learning: An experimental and individual difference investigation. *Journal of Personality and Social Psychology, 52,* 890–898. doi:10.1037/0022-3514.52.5.890

Harp, S.F., & Mayer, R.E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology, 90,* 414–434. doi:10.1037/0022-0663.90.3.414

Harriss, D., & Atkinson, G. (2009). Ethical standards in sport and exercise science research. *International Journal of Sports Medicine, 30,* 701–702. doi:10.1055/s-0029-1237378

Hennessy, S., Deaney, R., & Ruthven, K. (2003). *Pedagogic strategies for using ICT to support subject teaching and learning: An Analysis Across 15 Case Studies*. University of Cambridge Faculty of Education Research Report No. 03/1.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution and change. *Journal of Curriculum Studies, 37,* 155–192. doi:10.1080/0022027032000276961

Höffler, T.N., & Leutner, D. (2007). Instructional animation versus static pictures: A meta-analysis. *Learning and Instruction, 17,* 722–738. doi:10.1016/j.learninstruc.2007.09.013

Hu, L., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1–55. doi:10.1080/10705519909540118

Lavigne, G., Vallerand, R., & Miquelon, P. (2007). A motivational model of persistence in science education: A self-determination theory approach. *European Journal of Psychology of Education, 22,* 351–369. doi:10.1007/BF03173432

Legrain, P., Paquet, Y., d'Arripe-Longueville, F., & Antonini Philippe, R. (2011). Influence of desirability for control on instructional interactions and intrinsic motivation in a sport peer tutoring setting. *International Journal of Sport Psychology, 42,* 1–15.

Liebermann, D.G., Katz, L., Hughes, M.D., Bartlett, R.M., McClements, J., & Franks, I.M. (2002). Advances in the application of information technology to sport performance. *Journal of Sports Sciences, 20,* 755–769. doi:10.1080/026404102320675611

Mayer, R.E., & Chandler, P. (2001). When learning is just a click away: Does simple interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology, 93,* 390–397. doi:10.1037/0022-0663.93.2.390

Michas, I.C., & Berry, D.C. (2000). Learning a procedural task: Effectiveness of multimedia presentations. *Applied Cognitive Psychology, 14,* 555–575. doi:10.1002/1099-0720(200011/12)14:6<555::AID-ACP677>3.0.CO;2-4

Mouratidis, M., Vansteenkiste, M., Lens, W., & Sideridis, G. (2008). The motivating role of positive feedback in sport and physical education: Evidence for a motivational model. *Journal of Sport & Exercise Psychology, 30,* 240–268.

National Association for Sport and Physical Education (April, 2004). *Moving into the future: National standards for physical education* (2nd ed.). Columbus, OH: McGraw-Hill.

Ntoumanis, N. (2012). A self-determination theory perspective on motivation in sport and physical education: Current trends and possible future research directions. In G.C. Roberts & D.C. Treasure (Eds.), *Motivation in sport and exercise* (3rd ed., pp. 91–128). Champaign, IL: Human Kinetics.

OECD. (2006). *Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us*. Paris, France: Organization for Economic Co-operation and Development, OECD.

Papastergiou, M. (2010). Enhancing physical education and sport science students' self-efficacy and attitudes regarding information and communication technologies through a computer literacy course. *Computer Education, 54,* 298–308. doi:10.1016/j.compedu.2009.08.015

Papastergiou, M., Gerodimos, V., & Antoniou, P. (2011). Multimedia blogging in physical education: Effects on student knowledge and ICT self-efficacy. *Computer Education, 57,* 1998–2010. doi:10.1016/j.compedu.2011.05.006

Passey, D., Rogers, C., Machell, J., & McHugh, G. (2004). *The motivational effect of ICT on pupils*. Lancaster, UK: Department of Educational Research, University of Lancaster.

Plumert, J.M., Kearney, J.K., Cremer, J.F., Recker, K.M., & Strutt, J. (2010). Changes in children's perception-action tuning over short time scales: Bicycling across traffic-filled intersections in a virtual environment. *Journal of Experimental Child Psychology, 108,* 322–337. doi:10.1016/j.jecp.2010.07.005

Quested, E., & Duda, J.L. (2011). Antecedents of burnout among elite dancers: A longitudinal test of basic needs theory. *Psychology of Sport and Exercise, 12,* 159–167. doi:10.1016/j.psychsport.2010.09.003

Ratelle, C.F., Guay, F., Vallerand, R.J., Larose, S., & Senécal, C. (2007). Autonomous, controlled, and amotivated types of academic motivation: A person-oriented analysis. *Journal of Educational Psychology, 4,* 734–746. doi:10.1037/0022-0663.99.4.734

Russell, W.D., & Newton, M. (2008). Short-term psychological effects of interactive video game technology exercise on mood and attention. *Education Technology & Society, 11,* 294–308.

Ryan, R.M., & Connell, J.P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57,* 749–761. doi:10.1037/0022-3514.57.5.749

Sarrazin, P., Vallerand, R., Guillet, E., Pelletier, L., & Cury, F. (2002). Motivation and dropout in female handballers: A 21-month prospective study. *European Journal of Social Psychology, 32,* 395–418. doi:10.1002/ejsp.98

Schmidt, R.A. (1988). *Motor control and learning: A behavioral emphasis* (2nd ed.). Champaign, IL: Human Kinetics.

Selwyn, N., Gorard, S., Furlong, J., & Madden, L. (2003). Older adults' use of information and communications technology in everyday life. *Ageing and Society, 23,* 561–582. doi:10.1017/S0144686X03001302

Silverstone, R. (1996). Future imperfect: Information and communication technologies in everyday life. In W. Dutton (Ed.), *Information and communications technologies: Visions and realities* (pp. 217–232). Oxford: Oxford University Press.

Smeets, E., & Mooij, T. (1999). Time on task, interaction, and information handling in multi-media learning environments. *Journal of Educational Computing Research, 21,* 487–502.

Smith, A., Ntoumanis, N., Duda, J.L., & Vansteenkiste, M. (2011). Goal striving, coping, and well-being in sport: A prospective investigation of the self-concordance model. *Journal of Sport & Exercise Psychology, 33,* 124–145.

Stratton, G., & Finch, A. (2001). Information and communication technology in physical education: An ITTE-school partnership perspective. *British Journal of Teaching Physical Education, 32,* 24–26.

Taylor, I.M., & Lonsdale, C. (2010). Cultural differences in the relationships among autonomy support, psychological need satisfaction, subjective vitality, and effort in British and Chinese physical education. *Journal of Sport & Exercise Psychology, 32,* 655–673.

Taylor, I., Ntoumanis, N., Standage, M., & Spray, C. (2010). Motivational predictors of physical education students' effort, exercise intentions, and leisure-time physical activity: A multilevel linear growth analysis. *Journal of Sport & Exercise Psychology, 32,* 99–120.

Tearle, P. (2004). A theoretical and instrumental framework for implementing change in ICT education. *Cambridge Journal of Education, 34,* 331–351. doi:10.1080/0305764042000289956

Tearle, P., & Katene, W. (2005, September). The role, current practice and potential for use of Information and Communications Technology in Physical Education in UK secondary schools: A pilot study. British Educational Research Association conference, University of Glamorgan.

Tessier, D., Sarrazin, P., & Ntoumanis, N. (2010). The effect of an intervention to improve newly qualified teachers' interpersonal style, students' motivation and psychological need satisfaction in sport-based physical education. *Contemporary Educational Psychology, 35,* 242–253. doi:10.1016/j.cedpsych.2010.05.005

Thomas, A., & Stratton, G. (2006). What are we really doing with ICT in physical education: A national audit of equipment, use, teacher attitudes, support, and training. *British Journal of Educational Technology, 37,* 617–632. doi:10.1111/j.1467-8535.2006.00520.x

Trout, J. (2006, April). *Interactive video games in physical education*. Paper presented at the American Alliance for Health, Physical Education, Recreation, and Dance conference, Salt Lake City, UT.

von Hofsten, C., & Fazel-Zandy, S. (1984). Development of visually guided hand orientation in reaching. *Journal of Experimental Child Psychology, 38,* 208–219. doi:10.1016/0022-0965(84)90122-X

Wang, Q. (2008). A generic model for guiding the integration of ICT into teaching and learning. *Innovations in Education and Teaching International, 45,* 411–419. doi:10.1080/14703290802377307

White, R.W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review, 66,* 297–333. doi:10.1037/h0040934

Williams, A. (1997). *National curriculum gymnastics*. London, UK: Hodder & Stoughton.

Wood, J. (2005). Body and mind: A report on the use of ICT in PE. Coventry, WM: BECTa.

Wulf, G., & Shea, C. (2002). Principles derived from the study of simple skills do not generalize to complex skill learning. *Psychonomic Bulletin & Review, 9,* 185–211. doi:10.3758/BF03196276

Zhang, T., Solmon, M.A., Kosma, M., Carson, R.L., & Gu, X. (2011). Need support, need satisfaction, intrinsic motivation, and physical activity participation among middle school students. *Journal of Teaching in Physical Education, 30,* 51–68.