THE EFFECT OF LEARNER AUTONOMY ON MOTOR LEARNING: AN EMPIRICAL STUDY IN DUTCH VOCATIONAL EDUCATION

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This study investigated how student autonomy in physical education can be enhanced without producing adverse effects. A sample of 150 students from Dutch preparatory vocational education was divided into four groups subjected to different levels of autonomy during a physical education lesson. The autonomy conditions varied from teacher-led lessons to student-led task strategy selection, self-monitoring of task execution with video-based self-feedback and self-assessment of performance. Students in the autonomy conditions showed significantly higher motor performance than students in the teacher-led condition. Also, video-based self-feedback led to increased motor learning as compared to video-based teacher-led feedback. Students' self-assessment scores of exercise performance were found to converge very well with the scores assigned by the teachers. Finally, it was established that high performers benefited more from enhanced autonomy than low performers. Motivation was found to be high in all conditions, revealing no significant differences.

Keywords: physical education, autonomy, motor learning, preparatory vocational education, video-based self-feedback

Introduction

Children and young people increasingly suffer from overweight, which is generally attributed to a persistent lack of physical activity (Ness et al., 2007). A recent study across 195 countries revealed that 2.2 billion people, which is 30% of the world population, suffer from overweight and obesity (GBD 2015 Obesity Collaborators, 2017). Both are major risk factors for chronic diseases that include diabetes, cardiovascular diseases, and cancer. The authors of the GBD study have qualified obesity as a "rising pandemic" and a "global public health crisis" (p. 13). Obesity and overweight are readily attributed to a persistent lack of physical activity and other unfavorable lifestyle factors. A most reliable predictor of the future amount of physical activity is the level of education: in the course of their lives, low-educated people show less physical activity than high-educated people (Perlman & Karp, 2010; Pullus, Breedveld, & Van den Dool, 2015). Among all youth in the range of 12-17 years old in the Netherlands, students from the VMBO schools (lowest level in the Dutch school system) show the least physical activity (De Looze et al., 2014). Although physical education is considered an important instrument for influencing students physical activity levels and preserving these in the long term (Fairclough, Stratton, & Baldwin, 2002), the long-term effects are limited (De Looze et al., 2014).

When it comes to adopting and preserving an active lifestyle throughout one´s life, motivation is a crucial factor (Cox, Smith, & Williams, 2008; Haerens, Kirk, Cardon, De Bourdeaudhuij, & Vansteenkiste, 2010; Taylor, Ntoumanis, Standage, & Spray, 2010). Therefore, efforts of stimulating students' levels of physical activity at school should preferably be grounded in motivational considerations and underlying concepts. In accordance with Ryan and Deci's self-determination theory (Ryan & Deci, 2000), student autonomy has been established as a predominant factor driving student motivation in physical education (Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015). Autonomy in a learning context means students take control of their own learning (Knowles, 1975). Various studies have shown that students who can act more autonomously during physical education lessons are more self-determinedly motivated and more physically active (Cox et al., 2008; Hastie, Rudisill, & Wadsworth, 2013; Haerens et al., 2015; Perlman, 2015). Particularly, nonmotivated students engaged in the autonomy-supportive classes reported significantly higher levels of self-determined motivation (Perlman, 2015).

However, a survey among 1,019 secondary school students in the Netherlands showed that the amount of autonomy is generally low in physical education (Van Ekdom & Van Mossel, 2014). Also, students rarely have a say in the way performances are assessed (Borghouts, Van Dokkum, & Slingerland, 2014). This suggests that current approaches to physical education are largely teacher-controlled thus constraining the opportunities for student autonomy and enhanced motivation. However, a radical turn toward student-led pedagogies may produce adverse effects because an overdose of autonomy (e.g., laissez-faire) is known to likewise affect the efficacy of learning, quality of learning outcomes, and motivation (Wielenga-Meijer, Taris, Wigboldus, & Kompier, 2011). A key question to be answered is how autonomy in physical education can be enhanced without producing such adverse effects. Currently, no empirical data are available about the role of autonomy in physical education at the lowest preparatory vocational education level in the Netherlands. Moreover, most studies in physical education classes focus on motivation only while paying less attention to actual learning outcomes.

Our study focused on motor learning and, in particular, investigated empirically how different levels of autonomy influence students' motor learning outcomes in physical education lessons. Motor learning refers to the processes associated with practice or experience that leads to the acquisition of relatively permanent movement capability. Autonomy in the lessons was varied with respect to goal setting, task strategy selection, monitoring and evaluation of task execution, and the assessment of performance, respectively. Evidence of favorable effects will inform and help teachers and policymakers to procure the use of autonomy-based teaching methods that contribute to better learning outcomes, higher self-determined motivations, and potentially more active lifestyles in the long run.

Theoretical Framework

A variety of theoretical models of motivation have been proposed (e.g., Keller, 2008; Malone & Lepper, 1987; Ryan & Deci, 2000), all distinguishing between extrinsic motivation (referring to performing an activity driven by external factors; e.g., pressure, rewards, or salary) and intrinsic motivation (referring to the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, or to explore and learn). The achievement of sustained behavioral effects is best pursued by stimulating intrinsic motivation. There is abundant empirical evidence that intrinsically motivated students demonstrate more active behaviors during physical education lessons (Aelterman et al., 2012; Lonsdale, Sabiston, Raedeke, Ha, & Sum, 2009) as well as outside school (Cox et al., 2008; Haerens et al., 2010; Taylor et al., 2010).

Self-Determination Theory in Physical Education

This study is based on self-determination theory (SDT; Ryan & Deci, 2000). A crucial mechanism described in SDT is the (gradual) transition from extrinsic motivation to intrinsic motivation. This process of internalization (Deci & Ryan, 1985) describes how externally controlled behaviors are gradually adopted and integrated in the subjects' values and interests frames whereby they expose respective behaviors on a more voluntary basis. The principal concepts of SDT include different regulatory styles that cover the range between intrinsic and extrinsic motivation thus describing the progression of the internalization process. The following aggregate labels are commonly used (Ryan & Deci, 2000) to describe these regulatory styles and the associated classes of motivation:

- controlled motivation (emphasising external regulation);
- autonomous motivation (emphasising intrinsic regulation); and
- amotivation (when the subject is not motivated at all).

Autonomous motivation has an essential influence on the patterns of physical behaviors that students display (Cox et al., 2008; Van den Berghe, Vansteenkiste, Cardon, Kirk, & Haerens, 2014). Autonomously motivated students display better concentration (Ntoumanis, 2005), higher involvement, and higher activity levels in physical education lessons than students demonstrating controlled motivation or amotivation (Aelterman et al., 2012). Since physical activity is more meaningful to autonomously motivated students, higher activity levels are also displayed outside school (Cox et al., 2008; Haerens et al., 2010; Taylor et al., 2010). To get students autonomously motivated, their internalization process of externally-guided behavior regulation should be stimulated. Following SDT, this process can be facilitated by fulfilling the psychologic basic needs of relatedness, competence, and autonomy. Fulfilments of those innate needs would lead to individual growth, a sense of wellbeing, and optimal forms of motivation (Ryan & Deci, 2000).

The Balance between Student Control and Teacher Control

Teachers may help to amplify the autonomous motivation of their students by allowing them some control over their learning activities, which may have a positive influence on motivation and learning outcomes (Cox et al., 2008). However, a cautious balance between teacher control and student control is required to avoid ineffective learning modes such as developing misconceptions, spending too much time on unfavorable activities, or being deprived of feedback (Wielenga-Meijer et al., 2011). Teachers should offer an appropriate guidance structure; students should know what they are expected to do and how they can achieve good learning outcomes (Vansteenkiste, Sierens, Soenens, & Lens, 2007). Without a clear structure with guidelines, expectations, and feedback, the teaching deteriorates to laissez-faire, which is easily associated with limited teacher involvement, unguided exploration, or ultimately chaos and thereby has a negative impact on both motivation and learning outcomes (Jang, Reeve, Ryan, & Kim, 2009; Reeve, 2009). In contrast, full teacher control goes with clear assignments and abundant use of external motivators such as deadlines, rewards, punishments or marks, which may likewise frustrate students' basic psychological needs (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani, 2011). Full teacher control may readily lead to controlled motivation (DeMeyer et al., 2014), amotivation, opposition (Haerens et al., 2015), reduced involvement, and reduced learning outcomes (Assor, Kaplan, Kanat-Maymon, & Roth, 2005). Allowing for well-tuned student autonomy would avoid these problems.

Low-achieving students seem to benefit more from enhanced autonomy than high achievers do (Fei-Yin Ng, Kenney-Benson, & Pomerantz, 2004). Low achievers are more sensitive to experiencing successes because of low self-esteem with respect to competences and performances (Pomerantz & Saxon, 2001). Unfortunately, low achievers in the Dutch VMBO schools have been reported to be inherently weak at self-regulation and would still need substantial guidance (Hamstra & Van den Ende, 2006). The level of autonomy offered should match the students' metacognitive skills (Simons & Zuylen, 1995) or self-regulatory skills (Zimmerman, 2002), which include regulatory strategies such as orientation, planning, execution, monitoring, evaluation, and reflection. The low self-regulation ability of low achievers suggests that the degree of autonomy is somehow limited.

Simons and Zuylen (1995) have suggested that the level of student autonomy could be differentiated across different components of the educational process: (a) goal setting, (b) task strategy, (c) monitoring and evaluation of task execution, and (d) the assessment of performance. As students develop their regulative skills, they could be allowed to gradually control more components of the process. The components, which are used in this study to specify different levels of autonomy, are briefly explained below as follows:

- Goal setting. Goal setting in the context of physical education generally means that a motor activity is being set by the teacher for practicing. Nevertheless, giving students choice in selecting the motor activity increases their self-determination (Prusak, Treasure, Darst, & Pangrazi, 2004; Ward, Wilkinson, Graser, & Prusak, 2008).

- Task strategy selection. The selection of a task strategy in physical education is mainly based on the difficulty of the task. Partial or complete self-control of task difficulty is beneficial for motor learning (Andrieux, Boutin, & Thon, 2016).
- Monitoring and evaluation of task execution. Monitoring and evaluation of task execution through self-recording is also found to be beneficial for motor learning (Chiviakowsky & Wulf, 2005; Kolovelonis, Goudas, & Dermitzaki, 2011). Video-based self-feedback leads to better motor learning (e.g., higher skill progression) than prescribed video-based feedback because it creates deeper awareness and understanding of how a movement needs to be executed (Aiken, Fairbrother, & Post, 2012; Janelle, Kim, & Singer, 1995; Post, Aiken, Laughlin, & Fairbrother, 2016; Ste-Marie, Vertes, Law, & Rymal, 2012).
- Assessment. Assessment in Dutch physical education is usually covered by the teacher (Borghouts et al., 2014). Students generally tend to overrate their performances (Bjork, 1999; Kolovelonis & Goudas, 2012). In particular, at the VMBO level students feel their teacher is an authority who should provide corrective feedback (Groeneveld & Van Steensel, 2009).

Research Questions and Hypotheses

In this study, student groups in physical education were subjected to different levels of autonomy in order to investigate the potential effects on motivation and learning outcomes. Four autonomy levels are controlled by design. All four groups dealt with the same learning activity: the touch somersault, which is a standard flip exercise.

Autonomy conditions of the groups were differed by varying between teacher control and student control across learning task strategy, monitoring and evaluation of task execution, and the assessment of performance, respectively (Simons & Zuylen, 1995). Table 1 displays the four experimental conditions ordered toward ascending student autonomy.

Table 1. *Different Levels of Student Autonomy in Four Experimental Conditions*

Condition	Task strategy selection	Monitoring and evaluation of task execution	Assessment of performance
1	Teacher-controlled	Teacher-controlled	Teacher-controlled
2	Student-controlled	Teacher-controlled	Teacher-controlled
3	Student -controlled	Student-controlled	Teacher-controlled
4	Student-controlled	Student-controlled	Student-controlled

It is expected that giving students more autonomy would positively influence their motor learning (Filak & Sheldon, 2008; Jang et al., 2009). In addition, learners' motivations are expected to act as a mediator between autonomy and learning. Accordingly, research hypotheses are expressed as follows:

- Hypothesis 1: Students in conditions 2, 3, and 4 achieve higher learning outcomes than students in condition 1.
- Hypothesis 2: Students in conditions 3 and 4 will achieve the highest learning outcomes.
- Hypothesis 3: Motivation produces an indirect effect of autonomy on learning.

Method

The experiment uses a between-subjects design with the four conditions; student autonomy is the independent variable, and motor learning and motivation are the dependent variables.

Participants

For this experiment, 166 students from eight classes in IJsselcollege in the Netherlands were invited to participate. Eventually, after having received informed consent, 150 students (63% boys, 37% girls) from both first and second year classes participated. The age range of the sample was 12 to 15 years with a mean of 13.4 years and a standard deviation of 0.6 years. Group composition was arranged through stratification across four initial performance levels and self-regulation skills (see Procedure section).

Instruments

Performance of the touch somersault was measured by observation, supported by rubrics, for each of diverse motoric elements: push off, rotation, and landing. Each of the elements were rated on a 4-point scale. A maximum of 12 points could be achieved based on the task difficulty. With less task difficulty, fewer points could be achieved. The rubrics were developed by the teacher and researcher.

Self-regulating skills were measured with the Self-Regulation of Learning–Self-Report Scale (SRL-SRS; Toering, Elferink-Gemser, Jonker, Van Heuvelen, & Visscher, 2012). This questionnaire uses 46 items for covering planning, self-monitoring, self-evaluation, self-reflection, effort, and self-efficacy. Internal consistency of the items was found to be high for all scales with Cronbach's alphas of 0.81 (planning), 0.84 (self-monitoring), 0.90 (self-evaluation), 0.82 (self-reflection), 0.91 (effort), and 0.89 (self-efficacy).

Motivational regulation was measured with the Behavioural Regulations in Physical Education Questionnaire (BRPEQ; Aelterman et al., 2012), which is a Dutch adaptation of the Behavioural Regulation in Exercise Questionnaire (Markland & Tobin, 2004). It uses 20 items with a 5-point Likert scale to establish 5 motivation subscales: intrinsic regulation and introjected regulation (which combine into autonomous regulation), external regulation and identified regulation (which combine into controlled regulation), and amotivation. The internal consistency of intrinsic regulation, identified regulation, and amotivation in the sample were found to be high (Cronbach's alpha was 0.91, 0.83, and 0.82, respectively); however, Cronbach's alpha values for introjected regulation and external regulation were low (0.54 and 0.61, respectively) signifying low internal consistency. As a consequence, the use of the overall Relative Autonomy Index (Markland & Tobin, 2004), which is based on all five subscales of the BRPEQ, was abandoned.

Procedure

For the recruitment of participants, the school's management, teachers, students, and their parents were informed about the purpose and setup of the study, the voluntariness of participation, the preservation of anonymity, and what the data would be used for.

To determine the learners' entry levels, they all had to produce five trials of the touch somersault. After the trials, three video recordings of the touch somersault were made. The video recording of the best performance was used for assessment by the teacher and researcher. In all cases the teacher and researcher reached agreement about the assessments. After the video registrations were made, each group received its respective instructions.

Students with all permissions approved, completed the SRL-SRS. The four groups of the study were composed by stratified sampling across three strata of self-regulation skills from the SRL-SRS and four different prior performance classes. In addition, eight students who were graded by their physical education teachers as extremely weak performers and four students who were graded as extremely gifted performers were evenly distributed over the groups to avoid unwanted bias of performances. Variance analysis shows no significant differences between groups with respect to gender, $F(3,146) = 0.19$, $p = 0.904$; age, $F(3,146) = 0.62$, $p = 0.603$; class level, $F(3,146) = 0.05$, $p = 0.985$; motor skills, $F(3, 146) = 0.23$, $p = 0.878$; and self-regulation skills, $F(3, 146) = 0.04$, $p = 0.990$.

In each of the eight classes all four conditions were arranged, requiring four 1.5-hour lessons for each class of four groups: during the lessons, each group spent 15 minutes on their touch somersault session and could practice as much as they wanted while the other groups were playing a sports game. To avoid bias with the sequence order of groups in the classes, a rotational schedule was used to represent all different orders equally.

At the start of the lesson the students were briefed about the research and the setup of the lesson. Prior to exercise all students had to use their iPads to check the instructions about the touch somersault's components and their assessment criteria, explained through videos and texts. During exercise, students in all groups were allowed to consult their iPad at any time they wanted.

In all conditions, five different practice stations were offered to prepare for the touch somersault:

1. a low, declined gymnastic mat;

2. a high, declined gymnastic mat;
3. a low vaulting box with horizontal gymnastic mat on the ground;
4. a medium height vaulting box with gymnastic mat on the ground; and
5. a high vaulting box with gymnastic mat on the ground.

For students in condition 1, the teacher selected the order of practice stations whereas students in conditions 2, 3, and 4 were free to choose the practice stations by themselves (task strategy selection; cf. Table 1).

The monitoring and evaluation of task execution in this experiment was accommodated by a video-feedback application on the iPad. The application allowed for slow-motion playback, annotations, and measurement of relevant posture angles to analyze a movement in detail. In conditions 1 and 2, the teacher provided the video feedback whereas in conditions 3 and 4 students analyzed their movement by themselves. The self-timer function on the application made it possible for the students to use it without the help of others.

A performance retention test of the touch somersault was administered in the fourth (and final) lesson, which was 1 week after the training. During this final lesson students were not allowed to do movement analysis and substantive training. Prior to the assessment, the students did a maximum of five practice jumps as a warmup. Thereafter, they had three trials that were recorded. The video recording of the best performance was used for assessment. After this, students were invited to complete the BRPEQ to record their motivational regulation.

Findings

Effects of Autonomy on Motor Learning (Hypotheses 1 and 2)

The average motor performance level of 150 participants upon start of the experiment was 6.7 (*SD* = 2.1) on a scale from 1 (utterly weak) to 12 (excellent); during the final assessment the motor performance level was found to be 8.5 (*SD* = 1.8). This means there was an average motor learning outcome (viz., performance growth) of 1.8 points (*SD* = 1.5). Table 2 shows the motor learning outcomes per condition.

Table 2. *Mean Performance Growth for Each Condition With Standard Deviations and Effect Sizes*

Condition	Performance growth, *M*	*SD*	*ES*
1	1.4	1.2	1.2
2	1.6	1.2	1.3
3	2.3	1.2	1.9
4	2.1	1.2	1.8

Observed performance growth was different for each condition. All observed effect sizes qualify as very large (Sawilowsky, 2009). The Shapiro-Wilk test for the distribution of these learning outcomes suggested small deviations from normality, indicating skewness of -0.5 ($p < 0.001$) and kurtosis of -0.8 ($p < 0.001$). These deviations were small and hardly observable through visual inspection; therefore, parametric testing was deemed applicable because of its robustness against such minor deviations from normality. An analysis of covariance using motor performance level upon start as a covariate was carried out to test for significant differences of learning outcomes. First, this covariate was found to have a significant effect on motor learning, $F(1,144) = 69.50$, $p < 0.001$. The linear dependency coefficient of $b = -0.42$ indicated that motor learning outcomes are higher when initial motor performance levels are lower. Second, analysis of covariance revealed significant differences of motor learning across conditions, $F(3,144) = 3.79$, $p = 0.012$. Applying Helmert contrasts showed that motor learning in condition 1 was significantly lower than those in the other conditions ($p = 0.014$) thereby supporting hypothesis 1. Likewise, motor learning of participants in condition 2 (moderate level of autonomy) was found to be significantly lower than motor learning in conditions 3 and 4 (high autonomy; $p = 0.025$), which supports hypothesis 2. No significant differences were found between conditions 3 and 4 ($p = 0.646$).

Effects of Autonomy on Motivation (Hypothesis 3)

After removal of six outliers (the value of one of the variables was more than two standard deviations away from the mean), a Shapiro-Wilk normality test showed good normality for controlled motivation ($p = 0.075$) but deviations from normality for autonomous motivation ($p = 0.001$) and amotivation ($p < 0.001$).

Visual inspection showed that deviations from normality were small for both autonomous motivation and controlled motivation, but the distribution of amotivation was found to be highly skewed. Consequently, for amotivation a nonparametric test statistic was used (the Kruskall-Wallis H statistic) rather than an F statistic.

Table 3 presents the average motivations (averages from the Likert scores of the BRPEQ) for each condition.

Table 3. *Means and Standard Deviations of Autonomous Motivation, Controlled Motivation, and Amotivation for Each Condition*

Condition	Autonomous motivation		Controlled motivation		Amotivation	
	M	*SD*	*M*	*SD*	*M*	*SD*
1	2.6	1.0	1.1	0.6	1.1	1.1
2	2.6	1.0	1.3	0.6	0.9	1.0
3	2.6	0.8	1.2	0.7	1.0	0.9
4	2.7	0.8	1.2	0.5	0.7	0.8

As can be seen from the results in Table 3, the differences between conditions are not significant. This was confirmed by an F statistic for autonomous motivation, $F(3,140) = 0.26$, $p = 0.852$, and controlled motivation, $F(3,140) = 1.18$, $p = 0.320$, and an H statistic for amotivation (which showed a highly skewed distribution), $H(3) = 3.82$, $p = 0.282$. Thus, no evidence was found to support hypothesis 3.

Discussion

Motor Learning

Significant differences between groups were found for motor learning. Students in the autonomy conditions (2, 3, and 4) showed significantly higher learning outcomes than students in the teacher-led condition. Similarly, significant evidence was found that motor learning by participants correlated positively with the amount of autonomy provided. Students in conditions 3 and 4 (large degrees of autonomy) displayed significantly better motor learning outcomes than students in conditions 1 and 2 (limited autonomy). These outcomes suggest positive impact of learner autonomy on motor learning. Autonomy in task strategy selection and monitoring and evaluation of task execution based on video-based self-feedback led to increased learning outcomes. This agrees with previous studies by Andrieux et al. (2016) and Hartman (2007) that show that freedom of choice in psychomotor exercise improves motor performance. Furthermore, video-based self-feedback is associated with positive effects on motor skills (Aiken et al., 2012; Post et al., 2016; Ste-Marie et al., 2012). In contrast with existing studies that were arranged in a controlled lab situation, our study is ecologically sound in that it took place during regular classroom lessons.

Motivation

In all conditions, the score for autonomous motivation is fairly positive (M range of 2.6-2.7 using a 0-4 Likert scale). These positive outcomes might be explained because of the attractiveness of the learning activity (touch somersault) and the use of video instructions (Bund & Wiemeyer, 2004; Tsukazaki, Uehara, Morishita, Ninomiya, & Funase, 2012). The attractiveness of the task may have masked the influence of autonomy. However, no significant differences were found between the groups of learners (cf. Table 3). This means that the role of motivation as a mediator between autonomy and learning (hypothesis 3) was not supported. Several explanations may be considered. Motivation is a complex, multifaceted concept that is inherently difficult to measure accurately (Touré-Tillery & Fishbach, 2014). Indeed, the BRPEQ, even though specifically designed for physical education, displayed some low scale consistencies. Low scale consistencies might be due to limited reading comprehension skills of the participants involved as many of the students at the lowest levels of VMBO evidently suffer from limited reading comprehension and concentration problems (Hamstra & Van den Ende, 2006). Because of this low internal consistency of the instrument, the Relative Autonomy Index (Markland & Tobin, 2004) that indicates overall motivational states could not be used. For practical reasons, motivation data in this study could be gathered post-practice only thus making a pre-post comparison impossible. Since the BRPEQ was used post-practice and at the very end of the experiment, fatigue or disinterest may have further affected its reliability.

The Role of Video-based Self-feedback and Assessment

Our study demonstrates the positive effect of video-based self-feedback in physical education lessons in a quantitative way. So far, the studies of Aiken et al. (2012), Post et al. (2016), and Ste-Marie et al. (2012) have demonstrated positive effects of video-based self-feedback on motor learning be it in a controlled experiment outside the domain of physical education. Similar results were reported by O'Loughlin, Chróinín, and O’Grady (2013) and Weir and Conner (2009) in the context of physical education be it only as a qualitative inquiry. A quantitative study by Palao, Hastie, Cruz, and Ortega (2015) confirmed the effectiveness of video-feedback be it only for feedback by the teacher, not for the case of self-feedback. It has been suggested that allowing students to do the video analysis themselves (i.e., reviewing their own performances step by step, using slow motion, still frames, rewind, and toggle while consulting the rubric), creates deeper awareness and understanding of the ways they execute or should execute the required moves (Janelle et al., 1995). Also, video-based self-feedback leads to higher levels of self-efficacy because students have control over reviewing successful trials that leads to more confidence about their performance on their upcoming trials (Ste-Marie et al., 2012). Moreover, with the availability of a video-feedback tool, students are more independent and do not need to wait until the teacher helps them. However, studies from Bjork (1999) and Kolovelonis and Goudas (2012) have shown that students are generally weak at correctly self-assessing their physical performances; they tend to systematically overrate themselves. In our study, a comparison of the self-assessments with the teacher judgments shows different situations before and after the training sessions. Prior to the training sessions the average self-assessments were 1.42 points higher than the corresponding teachers’ scores (on a 12-point scale) and displayed an acceptable correlation of $r = 0.56$ ($p < 0.001$). This reflects a systematic overrating by students of their performances. After the sessions, student self-judgements and teacher judgements converged very well, showing a reduced difference of only 0.15 points and a strong correlation of 0.95 ($p < 0.001$). This is a relevant additional finding of this study, confirming the effectiveness of using video recordings for self-assessment.

High Performers Versus Low Performers

A secondary analysis of the data shows that high performers benefit more from enhanced autonomy than low performers. After having split the sample at the median score of prior performance, we found that high performers achieve significant learning outcomes, $F(3,84) = 3.68$, $p = 0.015$, while low performers generally do not, $F(3,57) = 0.12$, $p = 0.948$. The Tukey-HSD post hoc test reveals significant differences in motor learning of high performers between conditions 1 and 3 (1.1 points on a 12-point scale, *p* = 0.048) and between conditions 1 and 4 (2.2 points, *p* = 0.023), in favor of more autonomy; the more autonomy offered, the higher the learning outcomes. This observation is in accordance with the study of Cleary and Zimmerman (2001) that showed high performing athletes display better self-regulation skills than low performers and, thus, benefit more from conditions of autonomy (Simons & Zuylen, 1995). These results suggest that physical education teachers should differentiate between low performers and high performers when creating conditions of enhanced autonomy in their lessons.

Self-regulation skills may not be the only factor that explains the difference in motor learning between high performers and low performers when offering more autonomy. Also, the ability of the learner to process the available information to improve upon the skill level might be a crucial factor (Guadagnoli & Lee, 2004). Expert performers will be able to assimilate new information about the movement more efficiently than novices since their motor schemes are well developed (Schmidt, 1975). This is especially the case when video feedback is used. The effectiveness of video feedback depends very much upon the skill level of the performer (Kernodle & Carlton, 1992). Expert performers are able to analyze the movement by themselves, but for novice performers the information needs to be pointed out and supplemented with verbal cues (McCullagh, Ste-Marie, & Law, 2014). This means that for the use of video feedback low-performers may need more tutor-led feedback (teacher control) while high-performers benefit more from self-feedback (student control).

Outlook

The current study has established the positive influence of autonomy and self-regulation on motor learning in physical education lessons; however, a direct link between motivation and learning could not be established. The positive outcomes of using video-based self-feedback and self-assessment in physical education would deserve extensive new research in relation to motivation and motor learning. Also, within the scope of this study, long-term effects could not be taken into account. Once the learning in physical education classes would be optimized, longitudinal studies may be able to demonstrate the persistent influence of physical activity patterns acquired at school throughout one's life and, ultimately, its potential of reducing obesity.

References

Aelterman, N., Vansteenkiste, M., Vankeer, H., Van den Berghe, L., DeMeyer, J., & Haerens, L. (2012). Students' objectively measured physical activity levels and engagement as a function of between-class and between-student differences in motivation toward physical education. *Journal of Sport and Exercise Psychology, 34*(4), 457-480. doi:10.1123/jsep.34.4.457

Aiken, C. A., Fairbrother, J. T., & Post, P. G. (2012). The effects of self-controlled video feedback on the learning of the basketball set shot. *Frontiers in Psychology, 3*, 338. doi:10.3389/fpsyg.2012.00338

Andrieux M., Boutin A., & Thon, B. (2016) Self-control of task difficulty during early practice promotes motor skill learning. *Journal of Motor Behavior, 48*(1), 57-65. doi:10.1080/00222895.2015.1037879

Assor, A., Kaplan, H., Kanat-Maymon, Y., & Roth G. (2005). Directly controlling teacher behaviors as predictors of poor motivation and engagement in girls and boys: The role of anger and anxiety. *Learning and Instruction, 15*(5), 397-413. doi:10.1016/j.learninstruc.2005.07.008

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani C. (2011). Self-determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin, 37*(11), 1459-1473. doi:10.1177/0146167211413125

Bjork, R. A. (1999). Assessing our own competence: Heuristics and illusions. In D. Gopher D. & A. Koriat A. (Eds.), *Attention and performance XVII. Cognitive regulation of performance: Interaction of theory and application* (pp. 435–459). Cambridge, MA: MIT Press.

Borghouts, L., Van Dokkum, G., & Slingerland, M. (2014). Beoordelen in de lichamelijke opvoeding. *Lichamelijke Opvoeding, 4*(102), 6-8. Retrieved from https:/ /www.kvlo.nl/mysite/modules/MDIA0100/161_definitief_pdf_lo_4.pdf

Bund, A., & Wiemeyer, J. (2004). Self-controlled learning of a complex motor skill: Effects of the learner's preferences on performance and self-efficacy. *Journal of Human Movement Studies, 47*, 215-236. Retrieved from https://orbilu.uni.lu /bitstream/10993/4850/1/Publikation_Bund_2004_JoHMS_Learners%20Preferences.PDF

Chiviakowsky, S., & Wulf, G. (2005) Self-controlled feedback is effective if it is based on the learner’s performance. *Research Quarterly for Exercise and Sport, 76*(1), 42-48. doi:10.1080/02701367.2005.10599260

Cleary, T. J., & Zimmerman, B. J. (2001). Self-regulation differences during athletic practice by experts, non-experts, and novices. *Journal of Applied Sport Psychology, 13*(2), 185-206. doi:10.1080/104132001753149883

Cox, A., Smith, A. L., & Williams, L. (2008). Change in physical education motivation and physical activity behaviour during middle school. *Journal of Adolescent Health, 43*(5), 506-513. doi:10.1016/j.jadohealth.2008.04.020

Deci, E. L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality, 19*(2), 109-134. doi:10.1016/0092-6566(85)90023-6

De Looze, M., Van Dorsselaer, S., De Roos, S., Verdurmen, J., Stevens, G., Van Bon-Martens, M. J. H., & Vollebergh, W. (2014). *HBSC 2013: Gezondheid, welzijn en opvoeding van jongeren in Nederland.* Utrecht, Netherlands: Universiteit Utrecht.

DeMeyer, J., Tallir, I., Soenens, B., Vansteenkiste, M., Speleers, L., Aelterman, N., . . . Cardon, G. (2014). Does observed controlling teaching behavior relate to students’ motivation in physical education? *Journal of Educational Psychology, 106*(2), 541-554. doi:10.1037/a0034399

Fairclough, S., Stratton, G., & Baldwin, G. (2002). The contribution of secondary school physical education to lifetime physical activity. *European Physical Education Review, 8*(1), 69-84. doi:10.1177/1356336X020081005

Fei-Yin Ng, F., Kenney-Benson, G. A., & Pomerantz, E. M. (2004). Children's achievement moderates the effects of mothers' use of control and autonomy support. *Child Development, 75*(3), 764-780. doi:10.1111/j.1467-8624.2004 .00705.x

Filak, V., & Sheldon, K. M. (2008). Teacher support, student motivation, student need satisfaction, and college teacher course evaluations: Testing a sequential path model. *Educational Psychology, 28*, 711-724. doi:10.1080/01443410802337794

GBD 2015 Obesity Collaborators. (2017). Health effects of overweight and obesity in 195 countries over 25 years. *New England Journal of Medicine, 377*, 13-27. doi:10.1056/NEJMoa1614362

Groeneveld, M. J., & Van Steensel, K. (2009). Kenmerkend vmbo. *Een vergelijkend onderzoek naar de kenmerken van mbo-leerlingen, vmbo-leerlingen en de generatie Einstein.* Hilversum, Netherlands: Hiteq/Aetios.

Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behaviour, 36*(2), 212-224. doi:10.1260 /174795407789705505

Haerens, L., Aelterman, N., Vansteenkiste, M., Soenens, B., & Van Petegem, S. (2015). Do perceived autonomy-supportive and controlling teaching relate to physical education students' motivational experiences through unique pathways? Distinguishing between the bright and dark side of motivation. *Psychology of Sport and Exercise, 16*(3), 26-36. doi:10.1016/j.psychsport.2014.08.013

Haerens, L., Kirk, D., Cardon, G., De Bourdeaudhuij, I., & Vansteenkiste, M. (2010). Motivational profiles for secondary school physical education and its relationship to the adoption of a physically active lifestyle among university students. *European Physical Education Review, 16*(2), 117-139. doi:10.1177 /1356336X10381304

Hamstra, D. G., & Van den Ende, J. (2006). *De vmbo-leerling. Onderwijspedagogische-en ontwikkelingspsychologische theorieën*. Amersfoort, Netherlands: CPS.

Hartman, J. M. (2007). Self-controlled use of a perceived physical assistance device during a balancing task. *Perceptual and Motor Skills, 104*(3), 1005-1016. doi:10.2466/pms.104.3.1005-1016

Hastie P. A., Rudisill, M. E., & Wadsworth, D. D. (2013). Providing students with voice and choice: Lessons from intervention research on autonomy-supportive climates in physical education. *Sport, Education and Society, 18*(1), 38-56. doi:10.1080 /13573322.2012.701203

Janelle, C. M., Kim, J., & Singer, R. N. (1995). Subject-controlled performance feedback and learning of a closed motor skill. *Perceptual and Motor Skills, 81*(2), 627-634. doi:10.2466/pms.1995.81.2.627

Jang, H., Reeve, J., Ryan, R. M., & Kim, A. (2009). Can self-determination theory explain what underlies the productive, satisfying learning experiences of collectivistically oriented Korean students? *Journal of Educational Psychology, 101*(3), 644. doi:10.1037/a0014241

Keller, J. M. (2008). First principles of motivation to learn and e3-learning. *Distance Education, 29*(2), 175-185. doi:10.1080/01587910802154970

Kernodle, M. W., & Carlton, L. G. (1992). Information feedback and the learning of multiple-degree-of-freedom activities. *Journal of Motor behaviour, 24*(2), 187-195. doi:10.1080/00222895.1992.9941614

Knowles, M. S. (1975). *Self-directed learning: A guide for learners and teachers.* Cambridge, MA: Cambridge Book. doi:10.1177/105960117700200220

Kolovelonis, A., & Goudas, M. (2012) Students' recording accuracy in the reciprocal and the self-check teaching styles in physical education. *Educational Research and Evaluation, 18*(8), 733-747. doi:10.1080/13803611.2012.724938

Kolovelonis, A., Goudas, M., & Dermitzaki, I. (2011). The effect of different goals and self-recording on self-regulation of learning a motor skill in a physical education setting. *Learning and Instruction, 21*(3), 355-364. doi:10.1016/j.learninstruc .2010.04.001

Lonsdale, C., Sabiston, C. M., Raedeke, T. D., Ha, A. S., & Sum, R. K. (2009). Self-determined motivation and students' physical activity during structured physical education lessons and free choice periods. *Preventive Medicine, 48*(1), 69-73. doi:10.1016/j.ypmed.2008.09.013

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction: Vol. 3. Conative and affective process analyses* (pp. 223-253). Hillsdale, NJ: Lawrence Erlbaum.

Markland, D., & Tobin, V. (2004). A modification of the Behavioral Regulation in Exercise Questionnaire to include an assessment of amotivation. *Journal of Sport & Exercise Psychology, 26*, 191-196. doi:10.1123/jsep.26.2.191

McCullagh, P., Ste-Marie, D., & Law, B. (2014). Modeling: Is what you see what you get. In J. L. Van Raalte & B. W. Brewer (Eds.), *Exploring sport and exercise psychology* (pp. 139-162). Washington, DC: American Psychological Association. doi:10.1037/14251-007

Ness, A. R., Leary, S. D., Mattocks, C., Blair, S. N., Reilly, J. J., Wells, J., . . . Riddoch, C. (2007). Objectively measured physical activity and fat mass in a large cohort of children. *PLoS Medicine, 4*(3), e97. doi:10.1371/journal.pmed.0040097

Ntoumanis, N. (2005) A prospective study of participation in optional school physical education using a self-determination theory framework. *Journal of Educational Psychology, 97*(3), 444. doi:10.1037/0022-0663.97.3.444

O’Loughlin, J., Chróinín, D. N., & O’Grady, D. (2013). Digital video: The impact on children’s learning experiences in primary physical education. *European Physical Education Review, 19*(2), 165-182. doi:10.1177/1356336X13486050

Palao, J. M., Hastie, P. A., Cruz, P. G., & Ortega, E. (2015). The impact of video technology on student performance in physical education. *Technology, Pedagogy and Education, 24*(1), 51-63. doi:10.1080/1475939X.2013.813404

Perlman, D., & Karp, G. G. (2010). A self-determined perspective of the sport education model. *Physical Education and Sport Pedagogy, 15*(4), 493-505. doi:10.1080/17408980903535800

Perlman, D. J. (2015). Help motivate the amotivated by being a supportive teacher. *Physical Education and Sport Pedagogy, 20*(2), 204-214. doi:10.1177 /1356336X16643921

Pomerantz, E. M., & Saxon, J. S. (2001). Conceptions of ability as stable and self-evaluative processes: A longitudinal examination. *Child Development, 72*, 152-173. doi:10.1111/1467-8624.00271

Post, P. G., Aiken, C. A., Laughlin, D. D., & Fairbrother, J. T. (2016). Self-control over combined video feedback and modeling facilitates motor learning. *Human Movement Science, 47*, 49-59. doi:10.1016/j.humov.2016.01.014

Prusak, K., A., Treasure, D. C., Darst, P. W., & Pangrazi, R. P. (2004). The effects of choice on the motivation of adolescent girls in physical education. *Journal of Teaching in Physical Education, 23*(1), 19-29.

Pullus I., Breedveld K., & Van den Dool, R. (2015). *Sport is nog steeds vooral voor de elite. Sociale Vraagstukken*. Utrecht, Netherlands: Mulier Instituut. Retrieved from https:/ /www.socialevraagstukken.nl/sport-is-nog-steeds-vooral-voor-de-elite/

Reeve, J. (2009). Why teachers adopt a controlling motivating style toward students and how they can become more autonomy-supportive. *Educational Psychologist, 44*(3), 159-175. doi:10.1080/00461520903028990

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54-67. doi:10.1080/00461520903028990

Sawilowsky, S. (2009). New effect size rules of thumb. *Journal of Modern Applied Statistical Methods, 8*(2), 467-474. doi:10.22237/jmasm/1257035100

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review, 82*(4), 225. doi:10.1037/h0076770

Simons, P. R. J., & Zuylen, J. G. G. (1995). Van zelfstandig werken naar zelf verantwoordelijk leren. *Studiehuisreeks, 4*, 7-20. Retrieved from https://dspace .library.uu.nl/handle/1874/7008

Ste-Marie, D. M., Vertes, K. A., Law, B., & Rymal, A. M. (2012). Learner-controlled self-observation is advantageous for motor skill acquisition. *Frontiers in Psychology, 3*, 556. doi:10.3389/fpsyg.2012.00556

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 and Exercise Psychology*, *32*, 99-120. Retrieved from https://core.ac.uk/download/pdf /19142.pdf

Toering, T., Elferink-Gemser, M. T., Jonker, L., Van Heuvelen, M. J., & Visscher, C. (2012). Measuring self-regulation in a learning context: Reliability and validity of the Self-Regulation of Learning Self-Report Scale (SRL-SRS). *International Journal of Sport and Exercise Psychology, 10*(1), 24-38. doi:10.1080 /1612197X.2012.645132

Touré-Tillery, M., & Fishbach, A. (2014). How to measure motivation: A guide for the experimental social psychologist. *Social and Personality Psychology Compass, 8*(7), 328-341. doi:10.1111/spc3.12110

Tsukazaki, I., Uehara, K., Morishita, T., Ninomiya, M., & Funase, K. (2012). Effect of observation combined with motor imagery of a skilled hand-motor task on motor cortical excitability: Difference between novice and expert. *Neuroscience Letters, 518*(2), 96-100. doi:10.1016/j.neulet.2012.04.061

Van den Berghe, L., Vansteenkiste, M., Cardon, G., Kirk, D., & Haerens, L. (2014). Research on self-determination in physical education: Key findings and proposals for future research. *Physical Education and Sport Pedagogy, 19*(1), 97-121. doi:10.1080/17408989.2012.732563

Van Ekdom, H., & Van Mossel, G. (2014). Wat beweegt onze leerlingen? *Lichamelijke Opvoeding, 102*(7), 8-13.

Vansteenkiste M., Sierens E., Soenens, B., & Lens, W. (2007). Willen, moeten en structuur in de klas: Over het stimuleren van een optimaal leerproces. *Begeleid Zelfstandig Leren, 16,* 37-58. Retrieved from http://www.vfo.be/docs /vfostudiedag2007_vansteenkiste_BZL2007.pdf

Ward, J., Wilkinson, C., Graser, S. V., & Prusak, K. A. (2008). Effects of choice on student motivation and physical activity behavior in physical education. *Journal of Teaching in Physical Education, 27*(3), 385-398. doi:10.1123/jtpe.27.3.385

Weir, T., & Connor, S. (2009). The use of digital video in physical education. *Technology, Pedagogy and Education, 18*(2), 155-171. doi:10.1080 /14759390902992642

Wielenga-Meijer, E. G., Taris, T. W., Wigboldus, D. H., & Kompier, M. A. (2011). Costs and benefits of autonomy when learning a task: An experimental approach. *The Journal of Social Psychology, 151*(3), 292-313. doi:10.1080/00224545 .2010.481688

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*(2), 64-70. doi:10.1207/s15430421tip4102_2

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