

Original Article

Effects of learning strategies, styles and skill level on closed and semi-open motor skills acquisition

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Abstract:

Background: Achieving a winning formula for motor skills learning is a topic that has recently appeared in the educational scientific mainstream. It is known that different teaching methods may produce better learning results among learners at different learning levels. The purpose of this study was to examine the interaction between learning strategies and learning styles on closed and semi-open motor skills among novice and advanced learners under lab conditions. **Methods:** One-hundred and fifty volunteers were divided into three study groups according to the learning strategy they practiced: five-step, automatic, and technical enrichment (control). Each study group was further divided into two sub-groups according to their learning technique: variable and constant practices. Additionally, each sub-group was further divided into three groups according to the student's learning level: novice, intermediate, and expert. **Findings:** Our findings revealed that novice learners were most accurate during the acquisition and transfer phases in a constant practice learning technique while using the five-step learning strategy. Moreover, the combination of the five-step strategy and the variable practice learning technique was found to be the most beneficial for expert learners. **Conclusion:** We conclude that when learners are provided with proper learning tools, adjusted to their individual level and motor abilities, they will optimally improve their achievements and their motor performances.

Keywords: five-step approach; non-awareness strategy; variable practice

Introduction

Based on several studies (e.g. Hooper et al. 2006; Lin, Liu, and Yuan 2001), it has been argued that a more progressive multi-dimensional approach is needed to examine all the factors that are related to the student and the learning process, especially in the process of motor task acquisition. In motor skill learning there is a need to distinguish between the learners and several elements involved in the learning process that influence the learning's quality and outcomes. Motor learning studies have examined elements that embellish learning, such as learning strategies, learning styles, feedback, and others, while focusing separately on the influence of each element on motor skill acquisition. Learning strategies in the motor field are applicable as long as the learning environment allows students to organize their thoughts, such as during closed motor skills learning, when these skills are being performed in a fixed and predictable environment (i.e. basketball free throw) (Schmidt and Wrisberg 2008). This study focuses on two learning strategies that have been previously reported to be efficient in both lab and field studies: the five-steps approach (FSA) and the non-awareness strategy (NAS) (Lidor 2004; Singer, Lidor, and Cauraugh 1993, 1994).

Most studies that examined the efficiency of learning strategies were conducted in laboratory settings (e.g. Singer et al. 1994). For example, one such study found that students who were exposed to the FSA had better achievements in comparison to those who were not exposed to the FSA (Singer and Suwanthada 1986). Furthermore, the FSA was the most effective strategy for performing motor tasks that require the lowermost cognitive demands (Kim, Singer, and Radlo 1996). Another study found that using learning strategies results in higher accuracy than not using any learning strategy (Singer et al. 1993). Learning a motor skill is affected by: 1) Learning practices, 2) Level of the skill, 3) Characteristics of the skill, and 4) Transfer processes. Learning practice can be described as a way of practice that exposes new learning contents to the student (Schmidt and Lee, 2005; Schmidt and Lee, 2013; Schmidt and Wrisberg 2008). This practice allows the student to 'memorize', hence performing the learning task and assimilating it become part of his/her movement repertoire.

The influence of two learning practices, constant practice (CP) and variable practice (VP), on motor skill acquisition has been widely explored (e.g. McCracken and Stelmach 1977; Ota and Vickers 1999; Shea and Kohl 1990). A CP learning environment is characterized by fixed conditions, meaning that the environment does not change and the student practices the task many times under the same conditions, until he/she reaches a certain degree of self-satisfaction (Schmidt and Lee, 2013). In VP the student acquires a single motor skill while changes occur in the skill's main characteristics or in those related to the learning environment, such as distance,

power, and the angle of performance (Schmidt and Lee, 2013). One of the earliest studies in the motor learning area (McCracken and Stelmach 1977) examined the influence of CP on students who learned to evaluate time through pressing an electronic button. VP was found to have an advantage over CP in some studies (e.g. Dennis, Edward, and Malcolm 1993). However, in a replication study (Memmert 2006) no significant differences were found between the VP and the CP conditions, meaning that there was no long-term advantage for VP.

Since VP is characterized by the need to practice under several different conditions, and CP under a single condition, the question is whether the ability to cope with different, diverse learning levels is reflected in the students' skill level, meaning, will skilled students (experts) be able to acquire the skill if the learning process is more varied (VP), and will novice students learn better using CP? Expert students are defined as having high performance ability as a result of multi-year practice and experience (Foley and Hart 1992). Higher skill level is achieved by hard and intense practice, which is meant to assist the learner in assimilating movement and thinking patterns in a more effective manner (Ericsson 1996; Ericsson, Krampe, Tesch, and Roemer 1993).

There are several characteristics that differ between novice and expert students during learning. These include knowledge perception, information processing, and the use of information (Patel and Kaufman 1996; Shanteau 1992). Substantial differences between novice and expert students are also expressed during motor performance. A high level of control in both motor and cognitive perspectives is needed in order to succeed at a given motor task (Wrisberg 2001). In one study, it was reported that expert students had a higher level of decision making ability and of choosing adjusted tactical responses in order to put pressure on their opponents during a game than did novices (Villar, Gonzalez, Moreno, Cervelló, and Iglesias 2007). Similar results were found in studies conducted in different sports, such as tennis (Goulet, Bard, and Fleury 1989), baseball and badminton (Abernethy and Russell 1987). In a study by Lidor (1999), experts used environmental information to achieve higher efficiency, accuracy, and speed in comparison to novice students, and reached an automatic level of thinking with less awareness strategy when performing the task).

The purpose of the current study was to explore interactions between the FSA and the NAS, each in two learning practices – CP and VP, while acquiring closed and semi-open motor tasks among novice and expert students in laboratory settings. We had four hypotheses: 1) Novice students who are exposed to CP will acquire a motor task in a more accurate and precise manner in comparison to novice students who are exposed to VP; 2) Expert students who are exposed to VP will acquire a motor task in a more accurate and precise manner in comparison to expert students who are exposed to CP; 3) Novice students who acquire motor tasks using the FSA and CP will have better achievements in comparison to the rest of the novice students' groups; 4) Expert students who acquire motor tasks using the NAS and VP will have better achievements in comparison to the rest of the study groups.

Material and Methods

Participants

One-hundred and fifty physical education students (75 males and 75 females) at a Physical Education teacher preparatory college participated in this study (average age: 24 ± 3.5 years). Participants were divided into three ($n=50$) groups: FSA, NAS, and a control group that received technical enrichment for their performances without exposure to any learning strategy. Each group was further divided into novice and expert groups, in accordance with test results prior to the beginning of the study. The upper 30% of students with the average highest scores in each group were considered experts, while the lower 30% were considered novice.

Measures

Participants performed two different inner-rhythm motor tasks: closed – throwing a ball towards a board, and semi-open – kicking a ball towards a goal. These tasks were implemented as pre-tests and acquisition skills. Prior to exposure to a learning strategy or learning method, the participants performed five trials of each motor task as a pre-test assignment, in order to prevent a learning effect by the participants (Schmidt and Lee 2005).

Acquisition Closed Task: Throwing a ball towards a wall (Figure 1a). Participants threw a hollow plastic ball (diameter – 7cm; weight – 10gr) towards a wall, in an underhand throwing style, from a distance of 4.5m, aiming towards 10-line target areas on the ground (each line: length – 100cm; width – 70cm), separated by 10cm each, with the purpose of hitting the center target area (between the 5th and 6th lines), as presented in Figure 1a. Hitting the center area earned the participants a full score (10 points) while hitting anywhere else, either closer to the wall or farther, earned them a lower score. Any further line from the center earned participants a score decreased by two. Hitting the ball on a line between two scoring zones earned the participant the highest possible score.

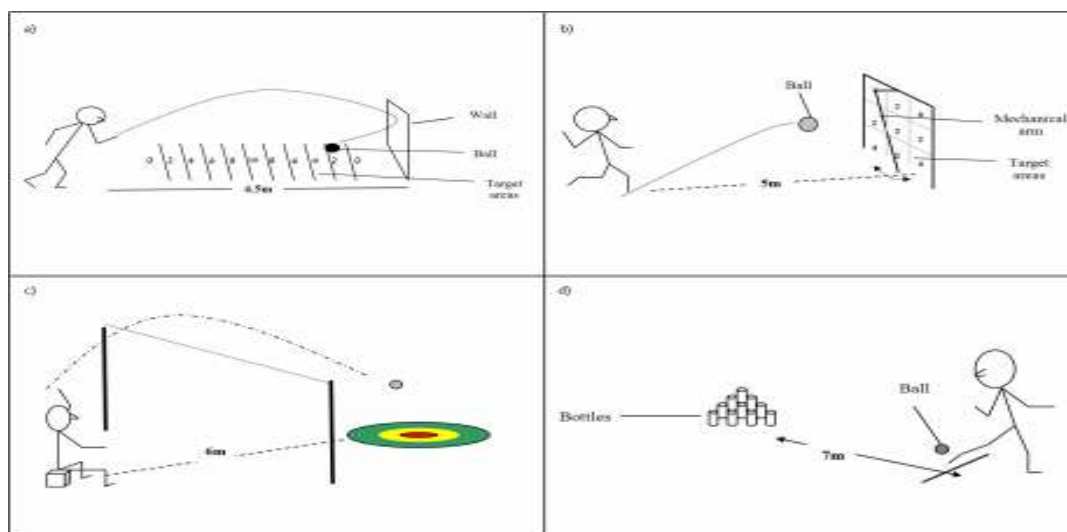


Fig. 1. The four tasks: a) An acquisition closed task – throwing a ball towards a wall, b) An acquisition semi-open task – throwing a ball towards a board, c) A transfer closed task – throwing the ball above an elastic band, d) a transfer semi-open task – a bowling kick.

Acquisition Semi-open Task: Kicking a ball towards a goal (Figure 1b). Participants kicked a sponge ball (diameter – 20cm; weight – 80gr) towards a wooden goal board (width – 1.5m; length – 1.5m) from a distance of 5m in a position of 90 degrees. The goal consisted of nine areas (3X3), with a different score for each. The upper goal corner areas = 6 points, lower corners = 4 points, and each of the remaining five middle areas = 2 points. A mechanical arm, simulating a goalkeeper, was attached to a wooden panel which moved at a changing speed run by an electrical mechanism (Voltage – 12 volt; power – 150 watt). The mechanical arm moved from one side of the goal to the other side during the participant's kick towards the goal, making it more difficult to aim. Scoring a goal at the upper corners was worth 6 points, at the lower corners 4 points, and 2 points at each of the remaining 5 areas. *Transfer Closed Task:* Throwing a ball above an elastic band (Figure 1c). Participants sat on a chair (height – 44cm) positioned diagonally to a circle target placed on the ground. The target was placed at a distance of 6m from the participant, and was divided into three different sized and colored hitting areas: center – red (diameter – 22cm) that was worth 6 points, middle – yellow (diameter – 45cm) worth 4 points, and outer – green area (diameter – 66cm) that was worth 2 points. At the middle distance point between the student and the target, an elastic band (width – 2cm; length – 3.5m; height – 1.3m) was stretched between two poles, while the aim was to throw a rubber ball (diameter – 24cm; weight – 160gr) in an upper strike technique above the band towards the target. Hitting the lines separating the two target zones earned the participant the higher score of these two zones. *Semi-open Task:* A bowling kick (Figure 1d). The participant stood in a side-position posture and kicked a sponge ball (diameter – 20cm; weight – 80gr) with his/her dominant leg toward 10 bottles (height – 40cm; weight – 2gr) from a distance of 7m. Bottles were organized into four rows of 1 (closest to the student), 2, 3, and 4 bottles each. The rows and the bottles were separated by 5cm. The aim was to knock down as many bottles as possible, with a single point awarded for every knocked-down bottle. Each attempt consisted of two kicks: the first kick was toward the entire 10 bottles organized as previously described, hence it was a closed task. The second kick was towards the remaining bottles after the first kick. Since the arrangement and the distance between the bottles changed between attempts, this task was considered as semi-open.

Procedures

Prior to beginning the study, approval was obtained from the College Institutional Review Board, and all participants provided written informed consent. The study consisted of eight meetings over five weeks. Participants performed five attempts each in two pre-tests during the first meeting. The random half began with the ball throw and the other half started with the goal kick; this was to prevent any influence of the task's order on achievements. According to their achievements, participants were assigned to one of three performance levels: novice, intermediate, and expert, in each of the following six study groups: (1) FSA+CP; (2) FSA+VP; (3) NAS+CP; (4) NAS+VP; (5) Control+CP; (6) Control+VP. In meetings two, three, and four, each group of students listened to a 7-min instruction recording consisting of 2 min of general information on the study and 5 min of specific instructions regarding the learning strategy (FSA or NAS). The control group also listened to a 7-min tape, which consisted of 2 min of general information on the study followed by 5 min of technical enrichment on the skills. Technical enrichment included information on the technical perspectives of the learning skills, and focused on the performance itself and not on learning strategy. During these meetings, the students

filled out a questionnaire examining their understanding of the learning strategy that they learned. After completing the questionnaires, the study researcher gave another explanation to those who did not fully understand the instructions. In every strategy or technical enrichment meeting the participants performed four series of the closed task (ball throw) and four series of the semi-open tasks (ball kick), and each series consisted of nine attempts (a total of 36 attempts in each task). Between each series a 60-sec rest was given, with a 5-min rest between each task. In the fifth and sixth meetings, participants were reminded with posters of the learning strategy/technical enrichment which they were supposed to implement. At the end of each meeting the participants were given a questionnaire consisting of four closed and four open questions, in order to evaluate how much of the instructions were implemented during the two tasks. At the end of the strategy and technical enrichment training phase (meeting seven), the first transfer phase was conducted. During this phase the participants performed two series of nine attempts for each task, without any given instructions. During the eighth meeting, the second transfer phase was conducted for the purpose of evaluating the amount of assimilation of the learning strategy among participants while performing additional tasks similar to the acquisition task.

Statistical analysis

A bi-lateral general linear model (GLM) (learning strategy X learning method X skill level X meeting X performance series) was used, with the meeting variables' repeated measures applied on each dependent variable and for each motor tasks separately. The least significant difference (LSD) post-hoc exam was performed when needed. Data from meetings seven and eight (transfer task) were analyzed using ANOVA (analysis of variance) between the study groups for each task separately. Significant level was set at 0.05 for all statistical comparisons.

Results

In the closed acquisition task, throwing a ball towards a board, student's skill level [$F(2,132)=661.97$, $p=0.00$] and the number of meetings [$F(5,660)=110.19$, $p=0.00$] were the two parameters that were significantly different between study groups. In the follow-up test, experts were more accurate in comparison to intermediate and novice students. In addition, all students were more accurate in the last meeting in comparison to the initial meeting.

Novice students in the control group who were exposed to CP were more accurate in comparison to the FSA and the NAS groups in the last five meetings [$F(4,132)=3.99$, $p=0.004$] (Figure 2a). Among novices who were exposed to VP, the control group students were more accurate in comparison to the FSA group in meetings 2 to 5. Intermediate students exposed to CP were more accurate while being instructed according the NAS in comparison to FSA in meetings 2 to 6, and in comparison to the control groups in meetings 3 to 6. Experts in the FSA and in the NAS who were exposed to CP were more accurate in comparison to the control group in meetings 2 to 4. Experts FSA students who were exposed to VP were more accurate than NAS in meetings 1 to 6 of the acquisition phase and meetings 2 to 6 in comparison to the control group.

In the semi-open acquisition task, a ball kick towards a goal, four parameters were found to significantly differ between study groups: Learning strategy [$F(2,132)=11.63$, $p=0.00$], learning practice [$F(1,132)=30.02$, $p=0.00$], skill level [$F(2,132)=289.185$, $p=0.00$], and the number of the meeting [$F(5,660)=119.94$, $p=0.00$]. In the follow-up test, the control group students were more accurate in comparison to both strategy groups. Students exposed to CP were more accurate in comparison to those exposed to VP. Experts were the most accurate followed by intermediate and novice students. The four dimensional interaction (learning strategy X learning practice X skill level X number of the meeting) was statistically significant [$F(20,660)=7.46$, $p=0.00$].

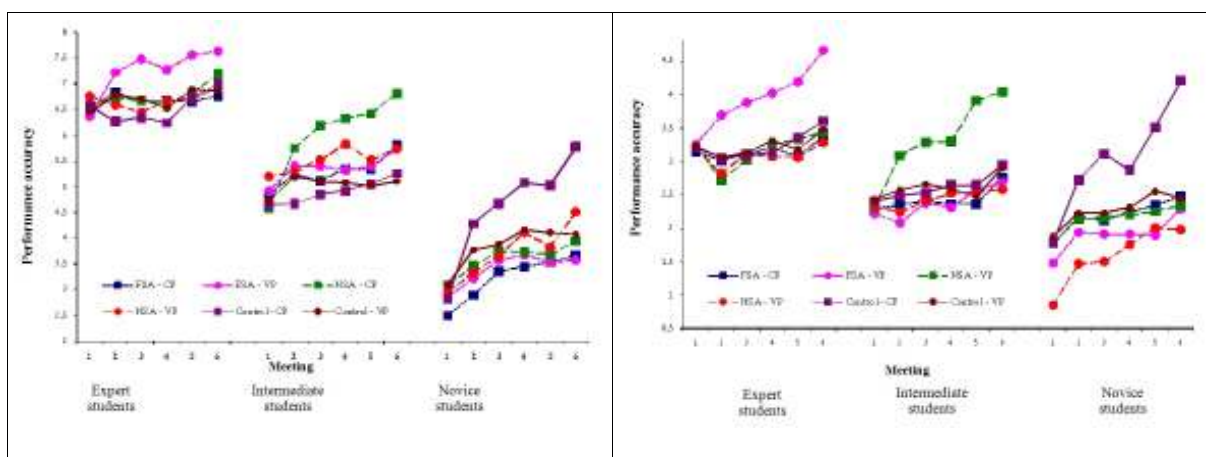


Fig. 2. The performance accuracy of the three study groups in a) the task of throwing the ball towards a wall, and b) the task of a ball kick towards a goal, during the six meetings.

Novice students in the control group who were exposed to CP were more accurate in comparison to the FSA and the NAS groups in meetings 2 to 5 (Figure 2b). Among novices who were exposed to VP, the control group students were more accurate in comparison to the FSA group in meetings 1 to 5 and in comparison to NAS group students in meetings 1 to 6. Intermediate students exposed to CP were more accurate while being instructed according the NAS in comparison to the FSA and control groups in meetings 2 to 6. Additionally, intermediate students exposed to VP from the control group were more accurate than students in FSA in meetings 1 to 4, and NAS students in meetings 2, 3, and 6. Experts in the FSA who were exposed to VP were more accurate in comparison to the NAS students in meetings 2 to 6, and in comparison to control group students in meetings 2, 4, 5, and 6. Variance analysis tests also resulted in five two-way statistically significant interactions relating to accuracy: (A) learning strategy by learning practice [F(2,132)=26.88, $p=0.00$]; (B) learning strategy by skill level [F(4,132)=37.658, $p=0.00$]; (C) learning practice by skill level [F(2,132)=36.38, $p=0.00$]; (D) learning practice by meeting [F(5,660)=2.56, $p=0.026$]; and (E) skill level by meeting [F(10,660)=10.62, $p=0.00$]. There were also four significant three-dimensional correlations: (A) learning strategy by learning practice by meeting [F(10,660)=7.32, $p=0.00$]; (B) learning strategy by skill level by meeting [F(20,660)=6.112, $p=0.00$]; (C) learning strategy by learning practice by skill level [F(4,132)=9.011, $p=0.00$]; and (D) learning practice by skill level by meeting [F(10,660)=3.94, $p=0.00$]. Figure 3a describes the three-dimensional correlation between learning strategy, learning practice, and skill level. From this interaction it is shown that novices in the control group who were exposed to CP were more consistent in their ball throwing in comparison to novices in the different strategy groups who were instructed with a similar learning practice. Intermediates in the NAS group who were exposed to CP were more consistent in comparison to intermediates in the FSA and control groups who were instructed with a similar learning practice.

In the closed transfer task, a ball throw above an elastic band, it appears from the two-way learning strategy by skill level interaction [F(4,132)=5.61, $p=0.00$] that novices from the control group were more accurate in comparison to novices in the FSA and NAS groups (Figure 3b).

In the semi-open bowling kick transfer task, a significant learning strategy by skill level interaction [F(4,132)=3.11, $p=0.018$] was observed (Figure 3c). Novice students from the FSA strategy were more accurate in comparison to novices in the control group. Intermediate students in the FSA group were more accurate than intermediates in the NAS and control groups, as opposed to experts in the control group who were more accurate in comparison to experts in the FSA group.

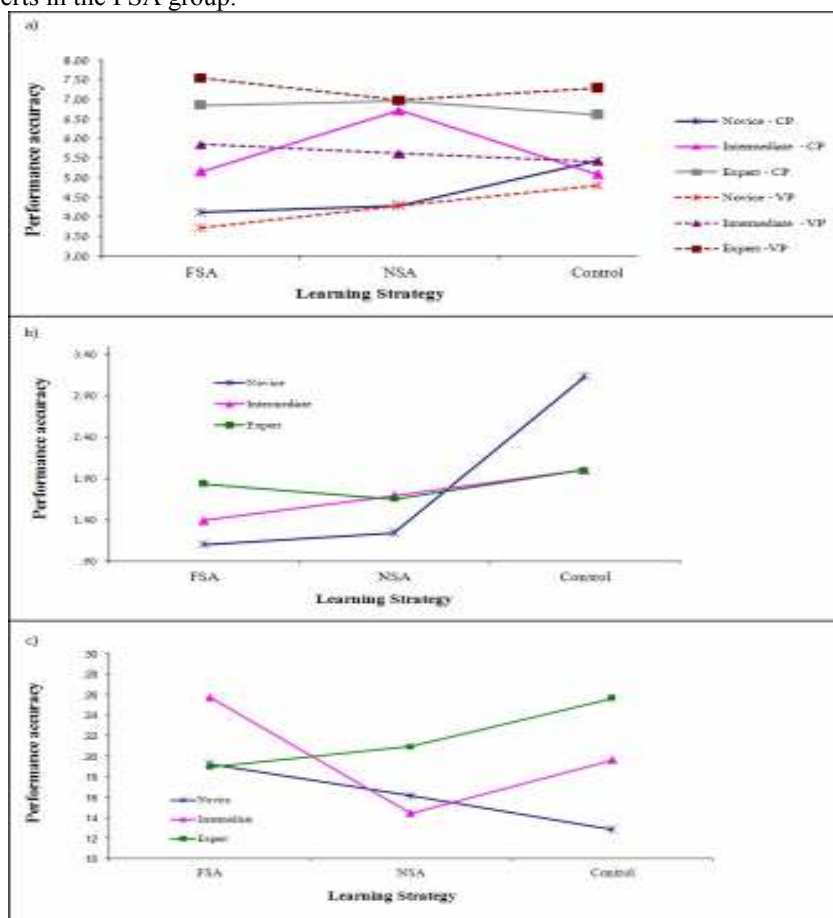


Fig. 3. The three-dimensional correlation among learning strategy by learning practice by skill level in the transfer phase of the task of a) throwing the ball towards a wall, b) ball throw above an elastic band, c) The learning strategy by skill level interaction during the transfer phase of the bowling kick task.

Discussion

The results of the current study support our first and second hypotheses, and show that novice students exposed to CP acquire motor skills in the most accurate way in comparison to novices exposed to VP, and that expert students who were instructed by VP performed the acquired motor skills better in comparison to experts who were exposed to CP, and better than novice and intermediate students as well. These findings are supported in other studies involving CP and VP conditions (Dennis et al. 1993; Schmidt and Wrisberg 2008; Shea and Kohl 1990), and may be explained by the fixed nature of the CP condition, which allows novices to adopt consistent movement patterns according to the skill's requirements. VP is more suitable for experts with a broad movement scheme that allows them to transfer knowledge from one learning environment to another (Schmidt and Lee 2013). It appears that the prior movement experience of experts allows them to cope in a better, more accurate and precise way with acquisition of new motor skills when there are several changes to the learning skill. Our third hypothesis was not supported by the results from the current study. In the current study, novice students in the control group were more accurate in the acquisition phase in comparison to students from the other two different learning strategies. A plausible explanation is that novices, who lack movement experience, are required during the acquisition phase of a new motor skill to implement cognitive instructions that require focus of attention in each phase of the performance. The novice students in our study experienced difficulty in acquiring this strategy, since they were at the beginning of the learning process and were not yet able to achieve appropriate technical control on the tasks' performances. The focus of attention among the non-experienced students was probably directed towards this technique; therefore, they had difficulties in implementing the strategy to which they were exposed. Perhaps combining different learning strategies in an early phase of skill acquisition poses an overflow of information, and makes it difficult for novice students to implement what they have just learned.

It is assumed that the FSA imaging phase among novices is not yet adequately developed, and the students have yet to experience success while performing any of the skills. Therefore, they will not be able to imagine and simulate themselves to succeed in the skill performance (Patel and Kaufman 1996), thus leading to a situation where they will not be able to produce the best from any learning strategy.

The fourth study hypothesis was that experts who acquired motor skills using the NAS and VP will be more accurate in comparison to the other study groups. This hypothesis was also rejected. Expert students among the FSA using VP were the most accurate ones in comparison to students in the NAS group and control group who were instructed by a similar learning practice. Additionally, intermediate students in the NAS who were instructed by CP and VP were more accurate in comparison to the FSA and control group students.

Several laboratory studies support our findings, and conclude that students who were instructed to use the FSA were found to be more accurate in comparison to students who were instructed in other learning strategies, such as the NAS and awareness strategy (Kim et al. 1996; Singer et al. 1993, 1994; Singer and Suwanthada 1986). All studies so far have evaluated the influence of a single learning factor, the learning strategy, on motor skill acquisition. In our study, the efficacy of the learning strategy was evaluated while being integrated with the learning practice and the student skill level. Based on our results, it can be seen that the FSA was the most efficient learning strategy for experts when combined with VP, and that the NAS was most effective when combined with VP and with CP for intermediate students.

The above findings can be explained by the fact that the FSA consists of five sub-strategies which provide the student with sufficient knowledge about what they should do prior to, during, and even post exercise (Lidor 2004). The FSA's aim is to assist the students in acquiring movement skills, in developing positive attitude towards the performance, in knowing how to deal with exterior and interior interferences during the performance, and in evaluating the entire learning process. The performer is not satisfied with just following orders – he/she is also trying to aim his/her thoughts towards positive channels, to analyze events, and to make decisions. Thus, the FSA represents aspects of both performance awareness and kinesthetic feedback utilization, in which the student is receiving and processing movement-related knowledge. This also occurs in the perspective of NAS, in which the student learns to focus his/her attention on a single exterior stimulus and on 'automatic' performance.

These findings support the Aptitude-Treatment Interaction (ATI) model, in which there is an interaction between different learning levels and the learning practices that are being implemented by the teacher in the learning process. Therefore, individual differences among students must be taken into consideration. These interpersonal differences may be expressed in variables such as the learning level and the student's motivational level. One of the main arguments put forth is that certain learning levels require a certain learning practice (Cronbach and Snow 1977). Studies in the field of education do not concentrate on which learning practice is better, but on which one is more efficient for which student population. The ATI's baseline assumption, which was supported in our study results, is that students with different learning levels and skills learn in different ways. Therefore, there is a need to adjust the varied learning practices to the different learners' individual abilities and characteristics.

Dissimilar learners need different combinations of learning strategies and learning practices. Novices need the combination of CP and a structured learning strategy, such as the FSA. The FSA combined with CP needs to be implemented under similar conditions. This combination will allow for both motor and cognitive

practices to be optimal. These cognitive tools may assist novices in acquiring other motor tasks in the learning process. Experts basically need VP combined with learning strategies that emphasize the automatic performance itself, such as the FSA and NAS. Expert students, under suitable conditions, will be able to improve their achievements and become active in physical education lessons with motivation and interest.

Conclusions

In school's reality, learners with difficulties are the first to give up on physical education classes. There is a high probability that if they are asked to be active in an experts' environment, or one that is not suitable to their level, they will reduce their physical activity. Thus, there is great importance in utilizing teaching instruments that will raise the student's self-confidence and the motivation to be physically active (Smith and Biddle 2008). To be able to reach all students, it is recommended that they be divided into different groups according to their motor abilities and skills. Although difficult for principals and teachers, the added value of activating a large number of students and providing solutions to their special needs is great, and supports the assumption that physical education lessons play a fundamental role in initiating movement and both closed and semi-open motor task acquisition. In addition, this will enhance the child's quality of life and will reflect a beneficial and valuable learning process. Furthermore, better acquisition of motor skills will allow a more successful transfer processes as part of a healthier lifestyle. This study raises the need to separate students into two main skill levels: novice and expert, while dividing the intermediate students into these two groups as well. At the physical education level, the teacher may separate the students into experts who practice with VP using NAS, and novices practice while being instructed with CP and FSA. When partitioning is based on systematic levels, then learning strategy of each group will be adjusted according to its skill level – thus leading to improvement and optimal performance.

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