

“Amplification of Error”: A Rapidly Effective Method for Motor Performance Improvement

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The aim of the current work was to test the effects of an innovative teaching method in improving motor skills. We evaluated the effectiveness of an error-based instruction method (Method of Amplification of Error, MAE) in increasing the performance of 13-year-old school students in the standing long jump. We compared MAE with direct verbal instruction (DI) and no instruction (Control group). The rationale for the MAE method is that giving a participant the opportunity to experience directly his or her own main movement error will trigger a positive searching strategy that will in turn help him or her to improve performance. The effectiveness of MAE is because of the type of feedback provided, namely the same motor-perceptive language used by the participant. Results showed that for the MAE and DI groups the length of jump increased from pre- to postinstruction, but postinstruction performance of the MAE group was significantly that of both of the other groups. It appears that MAE is an easy-to-use method for rapidly improving motor performance in the school teaching setting.

The correction of technique errors in motor skills represents one of the major issues in motor control and motor learning (Allison & Ayllon, 1980; Martin & Lumsden, 1987; Sherman & Rushall, 1993). Traditional methods of teaching are based on delivering extrinsic feedback by direct instruction or by demonstration. Verbal instruction is widely used in both physical education and sports while information kinematics feedback is used to correct aspects of the movement pattern (Newell & Carlton, 1987; Schimdt & Young, 1991). In addition, knowledge of performance (Gentile, 1972, Wallace & Hagler, 1979) has been shown to facilitate motor learning and to assist learners in correcting their errors (Reason, 1990) in different sport settings including rifle shooting (Boyce, 1991), ball toss (Janelle, Jingu, & Singer, 1995), basketball (Tzetzis, Kioumourtzoglou, & Mavromatis, 1997), throwing (Weeks & Kordus, 1998) and skiing (Tzetzis, Mantis, Zachopoulou, & Kioumourtzoglou, 1999). The content of a practitioner's feedback statement can be either descriptive or prescriptive in nature. A descriptive feedback statement

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merely indicates something about what the learner did (e.g., That's wrong, don't do it that way). Prescriptive feedback provides learners with information they can use to make corrections in their movement (e.g., Do it this way). Such feedback "prescribes" a solution to the individual's movement problem. Research suggests that prescriptive feedback is more useful to learners than descriptive feedback (Newell & McGinnis, 1985).

Demonstrations and other visual feedback represent forms of kinematic information learners can use to correct their errors. Moreover, with the advent of modern technology, this type of information can be easily presented through videotape or computer simulations of the desired action (Seat & Wrisberg, 1996; McCullagh & Weiss, 2001; Horn, Williams, & Scott, 2002).

Over the last several years different types of feedback have been proposed based on the assumption that practicing motor errors can actually strengthen motor learning. These techniques include "teaching backwards shaping," "reverse teaching progression" (Chelladurai & Stothart, 1978; Rushall & Ford, 1982; Spooner & Spooner, 1984; Spooner, Spooner, & Ulicny, 1986; Dusault, 1986; Sherman & Rushall, 1993), "negative practice" (Sharp, 1988) and the metacognitive learning strategy called "Old Way/New Way" (Lyndon, 1989, 2000; Lyndon & Dawson, 1995; Hanin, Korjus, Jousté, & Baxter, 2002; Cooke, 2003; Baxter, Lyndon, Dole, & Battistutta, 2004). The Method of Amplification of Error (MAE; Bragagnolo, Cesari, Facci, & Olivato, 1993; Cesari & Milanese, 1995; Cesari, Gallagher & Ross, 1996) represents another error feedback strategy for technique error correction. MAE is based on the assumption that participants can learn to correct their movements through their mistakes. The main theoretical premise of MAE is that movements are stored and reproduced by following rules regulated throughout the mastering of body constraints and degrees of freedom during the actual performance and not by storing specific central motor programs for a specific class of movements (see Adams' closed loop theory, 1971).

Consistent, habitual errors indicate the presence, rather than the absence of learning. With MAE, what matters is that the participant knows how to perform the movement incorrectly: one can say that mistakes represent the limits of the participant's of knowledge about one specific movement. According to Ausubel (1968): "*The single most important factor influencing learning is what the learner already knows. Ascertain this, and teach her/him accordingly*". Therefore, the performance of incorrect movements represents for the participant a real psycho-physical state that increases his or her awareness about the rules of the extreme limits of the movement. The participant then uses this information to direct the action adjustments needed to make the movement more successful. An additional premise of MAE is that among the many errors a participant makes during action execution, only a few are considered to be "principal" (i.e., the most influential with respect to the dynamic balance of the body in action), whereas the other secondary errors represent little more than compensatory adjustments. In a previous study by Cesari & Milanese (1995) using MAE to correct technical errors in tennis, the authors found that to intervene by amplifying the secondary error (i.e., a flexed elbow during the racket/ball impact in forehand stroke) was not successful. Indeed, after trials amplifying that error, the participant did not demonstrate any improvement. The authors then noticed that every time the participant performed the stroke with his or her elbow flexed, his general center of mass (COM) was behind the racket/ball

impact. The principal error was the incorrect position of the participant's projection of his or her COM. In fact, successive feedback focused on amplifying the wrong COM position and this did improve the performance.

A primary assumption is that by asking participants to amplify their principal error during a given performance, they achieve a better understanding of what not to do, therefore they are more capable of readjusting the entire motion during subsequent attempts. By amplifying the principal error performed, it is assumed that the participant triggers a positive searching strategy that helps him or her to improve the performance. Indeed, during corrective drills the participant, thanks to his or her short-term memory, is able to compare his or her own movement (learned error) to movement/input (amplification error). The amplified error trial provides the learner with new intrinsic feedback that enhances his or her error detection capability. While error detection capability is very important in the learning process, individuals usually do not use this feedback unless they are properly advised by an external observer to do so.

Tests of MAE in sport performance (Bragagnolo, et al., 1993; Cesari & Milanese, 1995, Cesari, et al. 1996) have shown the method to be effective in improving performance after only a few trials. For example, Cesari et al. (1996) compared the efficiency of providing amplified error feedback to traditional prescriptive feedback in 18 unskilled male and female participants hitting golf balls in a standard driving range. Feedback was based on two types of principal errors such as weight transfer and hip rotation during club-ball impact. It was found for the back and down swing path that the amplified error feedback group performed better than the prescriptive feedback group. These results have potential significance for the physical education setting because although practice is obviously necessary for learning a new motor skill, repeated correction of overlearned or recurrent error performance frequently leads to failure, even in the most committed and motivated students. Improved teaching effectiveness and reduced learning time are important goals for practitioners to achieve. Moreover, the amount and the frequency of feedback practitioners deliver have been shown to have either a positive or negative effect depending on the task and the skill level of the learner (Winstein & Schmidt, 1990; Weeks & Kordus, 1998). This issue was addressed in the current study by providing the same number of practice trials and delivering the same amount of feedback to each individual in each group.

The specific purpose of the current study was to compare the relative effectiveness of MAE to the traditional direct instruction method (DI) and to a no-feedback control condition in improving the performance of 13-year-old school students. The learning task was selected from the EUROFIT Motor Fitness Test: the standing long jump, (Adam, Klissouras, Ravazzolo, Renson, & Tuxworth, 1988). Fitness testing has been applied for different purposes. In the U.S. and Europe, it has been used for sport performance and in school physical education classes for evaluation purposes (Pate, 1989; Seefeldt & Vogel, 1989; Kemper & van Mechelen, 1996). More specifically, the standing long jump is frequently used to test the explosive lower limb strength of individuals. This very simple movement allows an immediate comparison between a person's actual performance and the biomechanically correct model even by naked eye, because only few variables must be taken into account according to the general basic structure of movement proposed by Meinel & Schnabel (1977). These authors have proposed a method for analyzing skilled actions by

dividing the action into three separate phases: preparatory, principal, and final. The analysis is conducted on the basis of the mechanical physiological aspects of the movement related to the specificity of the action (Meinel & Schnabel, 1977). With this three-phase approach, the standing long jump can be analyzed in a sufficiently precise way and the principal performance errors can be easily detected.

Method

Participants

Thirty public school students all aged 13 years (15 males and 15 females) participated in this experiment. Data collection was conducted in the gymnasium where students participated in their regular physical education lessons and in the presence of the class teacher to hold the target context constant (Schmidt & Wrisberg, 2008).

Procedure

Based on the guidelines proposed by Meinel & Schnabel (1977), we established the proper movement patterns necessary for performing a mechanically correct standing long jump. Specifically, during the jump preparatory phase the ankle, the knee and the hip joints angles should be altered in such a way that the general projection of the COM coincides with the center of the base of support under the feet. During the principal phase (the pushing phase) the joint angles should be completely open at the instant the feet leave the floor. Performance outcome was recorded for each individual on each trial by measuring the length of each jump. At the beginning of each trial, the participant stood on the gym mat behind a take-off line. The length of the jump was measured as the distance between the take-off line and the nearest point of foot contact at landing. For each condition, participants performed three jumps (pre and postinstruction) and then performed six trials under their respective instruction condition. All measurements were made by the same investigator. The experiment took place in three different sessions (within three weeks). During this time students attempted the standing long jump test only during experimental sessions. In the first session (the preinstruction condition) each participant performed the standing long jump for three trials and their average length was recorded. During this session, no specific instruction was provided but students were simply told they should swing both arms at the same time and take off with both feet in an attempt to jump as far as possible.

After averaging the measurements of three jumps for each participant, the students were divided into three different groups comprised of 10 individuals each. The three groups were designated as the MAE (Method of Amplification of Error) group, the DI (Direct Instruction) group and the C (Control) group. The following criteria were used for assignment: five males and five females in each group, care was taken to have a similar number of tall (166–180 cm, 30% of the participants), medium height (156–165 cm, 30% of the participants), and short (135–155 cm, 40% of the participants) performers in each group (see in Table 1 the mean length in each group for the preinstruction condition).

Table 1 Mean Length (\pm SD) of Long Jump for the Three Groups Before and After Instruction. Control (No Instruction); MAE, (Method of the Amplification of Error); DI, (Direct Verbal Instruction)

Group	Preinstruction condition (cm)	Postinstruction condition (cm)
Control ($n = 10$)	158.9 \pm 11.77	160.6 \pm 11.40
MAE ($n = 10$)	159.5 \pm 11.61	179.9 \pm 9.95*
DI ($n = 10$)	159.4 \pm 11.81	162.3 \pm 11.4

* $p < .001$ vs. Control; $p < .004$ vs. DI—Posthoc t test with Bonferroni correction.

During this session one author identified the learned principal error for each participant. In Table 2 we summarize the typical errors identified during the experiment. For example, during the preparatory phase a few students performed the jump with the trunk inclined forward with no flexion at the level of the knee joints. As a result the participant's general projection of the center of mass fell outside the base of support. This in turn had a negative affect on the performance of the following phase (the pushing phase). For other students, the main error was detected during the principal phase. They took off before the alignment of the legs and trunk was completed, decreasing the power of the push.

In the second session (instruction) both MAE and DI groups received their respective feedback from the same investigator (CM).

The MAE procedure included the following steps:

1. The instructor identified the main learned error demonstrated by each student based on the jumps performed in the first session. The two errors considered are reported in Table 2.
2. (a) "*the constrained trial*": The student was asked to perform the jump by amplifying the learned main error as defined by the instructor. Again, one of the two analyzed errors as explained in Table 2 was chosen, such that the feedback could change or not change trial after trial for each student depending on the error detected. In any case, in this trial it was very important that the participant exaggerated as far as possible the main error. Forced exaggeration helps the participant to make fruitful comparisons between movements, and thus understand the best way to make corrections; (b) "*the free trial*": The student was asked to perform the jump freely without any constraints. In this trial the participant should perform the movement better than in his original performance. Moreover, this trial is helpful for the teacher to understand if the participant is perceiving and using the feedback generated by the previous amplified error trial. If in the free trial the motion has not changed, the problem is either that the principal error has not been detected, or the participant did not sufficiently amplify the error. In the first case, the instructor would perform another evaluation of the movement observed to identify the principal error. In the second case the instructor would not alter the feedback but would ask the participant to repeat the movement, with more emphasis on the amplification of the mistake. If, instead, the instructor notes that the participant commits another type of main error, in later trials he must alter his feedback.

In this study steps a and b were repeated three times in an alternating sequence: trials 1-3-5 with amplified error feedback (see Table 2); trials 2-4-6 participants jump freely without any constraints. After Trial 1 some students had already demonstrated a good improvement with the amplification of the error defined by the instructor. Therefore, on Trials 3 and 5 the feedback was not changed. In the cases where very little improvement was observed, the participant was asked to increase the amplified error.

The DI procedure included the following steps:

1. The instructor identified the main learned error performed by each student based on the jumps performed in the first session (preinstruction, condition, see Table 2).
2. (a) "*the feedback trial*": The student was asked to perform the jump following the corrective verbal feedback given by direct instruction. In this study, we provided learners with the information that they could use to correct their movement by prescriptive feedback (e.g., Jump by extending completely the legs and trunk before taking off); (b) "*the free trial*": The student was asked to perform the jump freely without any constraints.

Steps a and b were repeated three times in order: Trials 1-3-5 with prescriptive feedback; Trials 2-4-6 participants jump freely without any constraints. On Trials 3 and 5 the instructor explained to the student what he or she did wrong and delivered the same verbal information about what he or she must do (prescriptive feedback).

In the Control Group students performed six jumps without receiving any instructions.

The third session (postinstruction condition) took place 1 week later to assess skill retention; each student performed three standing long jumps and the average length was calculated.

Between sessions the instructor requested that participants refrain from practicing the long jump. During the time students were at school, they did not perform the jump except during experimental sessions.

Statistical Analysis

A 3 (condition) \times 2 (session) repeated measures analysis of variance was conducted on the jump scores. A Bonferroni correction for multiple comparisons was used to evaluate any significant interaction. The level of statistical significance was set at $p < .05$ for main effects and $p < .008$ for follow-up analyses of a significant interaction.

Results

The most frequent movement error was observed during the preparatory phase of the jump and consisted of the anterior flexion of the trunk in association with a modest knee and ankle flexion; with this posture the center of mass is not over the base of support thereby hampering performance of the principal phase (the legs push). In the principal phase the most prevalent movement error was incomplete extension of the hip, knee, and ankle joints at the moment the feet left the floor.

The ANOVA revealed a significant main effect of session, $F(1,27) = 232 p < .01$ and a significant condition \times session interaction $F(2,27) = 122 p < .01$. Post hoc analysis of the interaction effect showed that while there was no significant difference in the pre- and post- session performance of the C group ($p = .09$), there was a significant improvement for both the DI group ($p = .003$) and the MAE group ($p = .003$). In addition, the performance of the MAE group was significantly higher than that of both the DI group and C group in the postinstruction session, $p < .01$ (see Figure 1).

Table 2 Error Detection and Feedback Delivered for the Two Instruction Groups (MAE and DI)

Error Analysis (Preparatory Phase)	MAE Feedback	DI Feedback
(a) The trunk is overinclined in a forward direction. No or too little bending of the legs.	(a) Increase the flexion of the trunk and keep the knees and ankles almost extended.	(a) Decrease the flexion of the trunk and increase the bending of legs.
Error Analysis (Principal Phase)	MAE Feedback	DI Feedback
(b) Both feet take off before trunk and legs reach the maximum extension and alignment.	(b) Push using only the feet, keeping knees (thigh) and hip (trunk) at a fixed angle.	(b) Before taking off extend completely the trunk and legs.

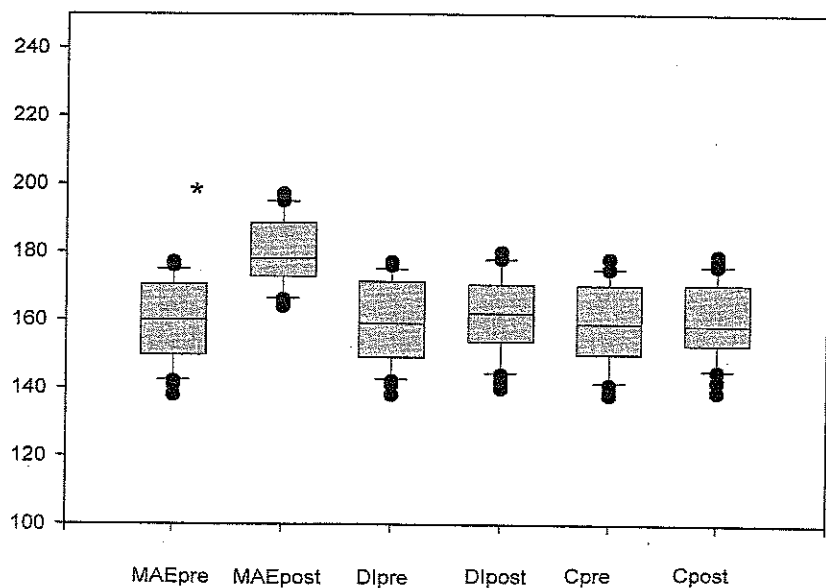


Figure 1 — Jump on the pre- and the posttest for the three conditions.

Discussion

The aim of this work was to determine whether MAE would be effective in improving motor skill learning in the gymnasium where students participate in their regular physical education lessons. We compared the effect of two types of instruction and a no-instruction control condition on the performance of 13-year-old students in the standing long jump. Results revealed that the postinstruction performance of the group that received MAE instruction was significantly higher than of the other two groups, which did not differ from each other.

Thus, it appears that MAE was an effective method of instruction for promoting rapid improvements in the standing long jump performance of the participants in this study. The main advantages of MAE instruction are: (a) it is rapidly effective; (b) it employs movement as feedback and the feedback is defined in the motor-perceptive language used by the participant. The basic concept underlying MAE instruction is that among several errors in a given movement there is a single principal error (i.e., the most influential for task performance) and it has the greatest affect on the performance outcome. Secondary errors are assumed to be reflective of compensatory adjustments to achieve the final movement.

Compared with traditional instruction methods, the MAE method presumably requires the participant to detect the main error and then devise a solution by applying an autonomous searching strategy (McDonald, Oliver, Newell, 1995). Put simply, the learner is the one who is responsible for learning, understanding, and changing.

MAE instruction refrains from using extrinsic feedback information that would encourage learner dependence and diminish learning; instead, MAE relies on internally generated feedback processes to enhance participants' capability of producing the correct movement on their own. It should be pointed out, however, that the experienced instructor must correctly identify the principal learned error in a given movement.

The MAE strategy is simple and effective as long as the teacher is able to do the following:

1. Identify and diagnose the principal learned error, i.e., the factors that represent the main cause and not the secondary effects of the movement. This is a critical issue because in most practical learning situations, sophisticated instruments to assess performance are not available, and the teacher typically observes the learner's movement using the naked eye. We have found it useful to compare the participant's movement with the theoretical biomechanical model, proposed by Meinel & Shnabel, (1977).
2. Choose the "principal error", i.e., the one that primarily affects the integrity of the structure and performance of the movement;
3. Deliver the correct "value," in term of joint amplitude, needed to adapt the action.

In this work we compared MAE and DI instruction for correcting errors in a simple jumping movement; therefore, the comparative effectiveness of MAE and DI in correcting more complex movements remains to be determined. Previous studies using MAE instruction in complex sport specific movements (Bragagnolo, et al. 1993; Cesari & Milanese, 1995, Cesari et al. 1996), however, have consistently shown improved motor performance after self-detection of

error by the athlete. The present study extends previous findings by showing that MAE is also effective for teaching younger students a simple skill, (Bragagnolo, et al. 1993; Cesari & Milanese, 1995, Cesari et al. 1996). Taken together, the results of this and previous research suggest that MAE is an effective technique for correcting the pattern of motion quickly in a short time; in contrast, conventional approaches of error correction usually take longer than one session.

In summary, MAE differs from conventional methods of motor error correction in several ways:

1. The incorrect movement represents for the participant a real psycho-physical state and, for the teacher, the starting point for correction. Performance errors are considered a sign that learning has occurred, rather than a sign of learning failure or an inability to learn; learned error must be recognized and exploited, not ignored.
2. The corrective movement (the constrained trial by amplifying error) employs the same body segments involved in the learned error but amplifies the learned main error identified by the trainer. So, the amplified error trial helps the learner to compare different motion patterns with the performance results (e.g., the length of the jump).
3. The amplified error trial, besides providing the learner with new intrinsic feedback, stimulates the functions of perceptive categorization and the conceptual and symbolic elaboration of the received information, therefore improving his or her error detection capability.
4. Amplifying the participant's "main" error in a given motor skill allows him or her to better understand what is not-to-be-done, thereby enhancing the correction of motor errors. Traditional training (DI) simply points out the error and then goes straight into showing the person what she or he is doing wrong (descriptive feedback), what they should be doing instead (prescriptive feedback) and then getting him or her to practice the right way straight off. The remedy is to reteach the task and give practice in drills. Although learners might appear to pay attention during training and practice their new, correct skills and knowledge over and over, after a few minutes or the next day or under the pressure of competition, they forget what they have learned and the same pattern error resurfaces. The major problem with the conventional approach to error correction is that it takes a long time and the change is often not permanent. The different approach of MAE is that it is an unlearning task rather than a reteaching one. In this way the participant deletes forever the error with a full transfer of learning, without the need for the customary adaptation period. Cesari & Milanese (1995) showed that skill improvement also directly transfers to competitive matches, as shown in their case studies
5. The participant can be empowered through MAE to take more responsibility for the learning strategy adopted.

Additional research is underway to evaluate the persistence of MAE instruction effects over time and their impact on the learning of more complex movements.

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References

- Ausubel, D. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart and Winston.
- Adams, J.A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, 3, 111-150.
- Adam, C., Klissouras, V., Ravazzolo, M., Renson, R., & Tuxworth, W. (1988). *Eurofit: European Test of Physical Fitness*. Rome: Council of Europe, Committee for the Development of Sport.
- Allison, M.G., & Ayllon, T. (1980). Behavioral coaching in the development of skills in football, gymnastics and tennis. *Journal of Applied Behavior Analysis*, 13, 297-314.
- Baxter, E.P., Lyndon, E.H., Dole, S., & Battistutta, D. (2004). Less pain, more gain: Rapid skill development using old way/new way. *Journal of Vocational Education and Training*, 56(1), 21-50.
- Boyce, B.A. (1991). The effects an instructional strategy with two schedules of augmented feedback upon skill acquisition of a selected shooting task. *Journal of Teaching in Physical Education*, 11, 47-58.
- Bragagnolo, W., Cesari, P., Facci, G., & Olivato, P. (1993). *Apprendimento e ridimensionamento motorio*. Rome: Società Stampa Sportiva.
- Cesari, P., & Milanese, C. (1995). What can we learn from mistakes? *Coaching & Sport Science Journal*, 1, 19-28.
- Cesari, P., Gallagher, J., & Ross, M. (1996). Amplification of error: Does exaggerating error improve motor skill learning. *Journal of Sport and Exercise Psychology*, 18s, 21.
- Chelladurai, P., & Stothart, C. (1978). Backward chaining: A method of teaching motor skills. *CAHPER Journal*, 44 (1), 16-19, 36-37.
- Cooke, G. (2003). Old way new way. *Sports Coach*, 24(4), Australian Sports Commission.
- Dusault, C. (1986). A backward shaping progression of the volleyball spike approach and jump. *Volleyball Technical Journal*, 8, 33-41.
- Gentile, A.M. (1972). A working model for skill acquisition with application to teaching. *Quest Monograph*, 17, 3-23.
- Hanin, Y., Korjus, T., Jouste, P., & Baxter, P. (2002). Rapid technique correction using old way/new way: Two case studies with Olympic athletes. *The Sport Psychologist*, 16, 79-99.
- Horn, R.R., Williams, A.M., & Scott, M.A. (2002). Learning from demonstrations: The role of visual search during observational learning from video and point-light models. *Journal of Sports Sciences*, 20(3), 253-269.
- Janelle, C.M., Jingu, K., & Singer, R.N. (1995). Subject-controlled performance feedback and learning of a closed motor skill. *Perceptual and Motor Skills*, 81, 627-634.
- Kemper, H.C.G., & van Mechelen, W. (1996). Physical fitness testing of children: a European perspective. *Pediatric Exercise Science*, 8, 201-214.
- Lyndon, E.H. (1989). I did it my way! An introduction to old way/new way. *Australian Journal of Special Education*, 13, 32-37.
- Lyndon, E.H. (2000). *Conceptual mediation: A new theory and new method of conceptual change*. Unpublished doctoral dissertation, University of Adelaide, Australia.

- Lyndon, E.H., & Dawson, C.J. (1995, June). The conceptual mediation program: A practical outcome from a novel perspective on conceptual change. Paper presented at the Australian Association of Science Education Annual Conference, Adelaide.
- Martin, G.L., & Lumsden, J.A. (1987). *Coaching - An effective behavioral approach*. St. Louis, MO: Mosby.
- McCullagh, P., & Weiss, M.R. (2001). Modeling: Considerations for motor skill performance and psychological responses. In R.N. Singer, H.A. Hausenblas, & C.M. Janelle (Eds.), *Handbook of Sport Psychology* (2nd ed.), (pp. 205-238). New York: Wiley.
- McDonald, P.V., Oliver, S.K., & Newell, K.M. (1995). Perceptual-motor exploration as a function of biomechanical and task constraints. *Acta Psychologica*, 88(2), 127-165.
- Meinel, K., & Schnabel, G. (1977). *Bewegungslehre Sportmotorik, Abriß einer Theorie der sportlichen Motorik unter pädagogischem Aspekt*. Berlin: Volk und Wissen.
- Pate, R.R. (1989). The case for large-scale physical fitness testing in American youth. *Pediatric Exercise Science*, 1, 290-294.
- Reason, J. (1990). *Human error*. Cambridge, MA: Cambridge University Press.
- Rushall, B.S., & Ford, D. (1982). Teaching backwards - an alternative skill instruction progression. *CAHPER. Journal*, 48(5), 16-20.
- Newell, K.M., & Carlton, M.J. (1987). Augmented information feedback and the acquisition of isometric tasks. *Journal of Motor Behavior*, 19, 4-12.
- Newell, K.M., & McGinnis, P.M. (1985). Kinematic information feedback for skilled performance. *Human Learning*, 4, 39-56.
- Schmidt, R.A., & Wrisberg, C.A. (2008). *Motor learning and performance* (4th ed.). Champaign, IL: Human Kinetics.
- Schmidt, R.A., & Young, D.E. (1991). Methodology for motor learning: A paradigm for kinematic feedback. *Journal of Motor Behavior*, 23, 13-24.
- Seefeldt, V., & Vogel, P. (1989). Physical fitness testing of children: A 30-year history of misguided effort? *Pediatric Exercise Science*, 1, 295-302.
- Sharp, R. (1988). Error in the price of skill. *British Journal of Physical Education*, 19, 127-129.
- Sherman, C.A., & Rushall, B.S. (1993, March). Improving swimming stroke using reverse teaching: A case study. *Applied Research in Coaching and Athletics Annual*, 123-143.
- Seat, J.E., & Wrisberg, C.A. (1996). The visual instruction system. *Research Quarterly for Exercise and Sport*, 67, 106-108.
- Spooner, F., & Spooner, D. (1984). A review of chaining techniques: Implications for further research and practice. *Education and Training of the Mentally Retarded*, 19, 114-124.
- Spooner, F., Spooner, D., & Ulicny, G. (1986). Comparisons of modified backward chaining: Backward chaining with leapaheads and reverse chaining with leapaheads. *Education & Treatment of Children*, 9, 122-134.
- Tzetzis, G., Kioumourtoglou, E., & Mavromatis, G. (1997). Goal setting and feedback for the development of instructional strategies. *Perceptual and Motor Skills*, 28, 1411-1428.
- Tzetzis, G., Mantis, K., Zachopoulou, E., & Kioumourtoglou, E. (1999). The effect of modelling and verbal feedback on skill learning. *Journal of Human Movement Studies*, 36, 137-151.
- Wallace, S.A., & Hagler, R.W. (1979). Knowledge of performance and the learning of a closed motor skill. *Research Quarterly*, 50, 265-271.
- Weeks, D.L., & Kordus, R.N. (1998). Relative frequency of knowledge of performance and motor skill learning. *Research Quarterly for Exercise and Sport*, 69, 224-230.
- Winstein, C.J., & Schmidt, R.A. (1990). Reduced frequency of knowledge of results enhances motor skill learning. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, 16, 677-991.