Coaching Science

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1. General Information

General Coaching Science/Theory pertains to what is common in coaching all sports, while Sports-Specific Coaching Science/Theory deals with coaching a specific sport. This chapter is confined to General Coaching Science/Theory.

The change from the modern concept of the science of coaching to coaching science shows a trend towards a discipline based on specialised knowledge, unique research methods and structured training spheres.

This recent science focuses on two areas:

1. Coaching as a process for target acquisition in competitive sport within an organised ompetition system; and
2. Coaching as a process of different physical activities and in a range of sport fields where the primary aim is health, weight reduction, healthy body and mind.

Coaching science is the kernel of sport sciences (Hohman, Lames and Letzelter, 2003). Today, more than ever, there is a methodological base with an understanding that coaching theory both as a theory and as a methodology is not just applicable to elite sport.

1.1. Historical Developments

Until the 20th century, coaching was done by instinct, tradition and personal trial and error. A real theory began to develop (mainly in measurable sports, such as track and field, and on the subject of developing physical ability) when coaches called upon experts in exercise physiology for advice. By the 1950s, coaching theory came of age, initially in the Soviet Union and its satellites, with the work of Matveyev et al., on coaching theory, especially on periodisation of training. The East-West competition, with attendant government support, fuelled both coaching practice and the development of coaching theory. In the 1970s, upgrading coaching by means of increased volume had reached its limits and increasing intensity was called upon; but this, too, was nearing its bounds. So, in the 1980s, coaching theory (and practice) turned to periodical shifting of emphasis on different elements of ability, on increased specificity of exercise and on ergogenic aids (initially of metabolic, later of hormonal nature).

Coaching science, which began as a copy of successful methods of coaches, today focuses on the question of “why”, via interdisciplinary research and asks the questions of what is the best method for the effectiveness of coaching over the short, medium and long terms in the areas of preventative, sport functioning and rehabilitation.

The search for the scientific base accompanies the theory and structured methodology (the theory of coaching), which cannot exist in disciplinary sciences that do not have a direct base on which to work (Wertheim, 2004). Coaching sciences today are not based on pedagogical principles, as they were in the past, and on the physiological principles of a few years ago, but on the interaction between them with the understanding of the connection between the educational process in coaching and the physiological process.

Nowadays, ergogenic aids are being frowned upon and coaching theory turns to emphasising psychological training, biofeedback, “delayed response” training and, with the shift from government to commercial funding, to developing coaching theory for the leisure-sports athlete.

1.2. Function

Coaching sports is the act of leading/guiding an athlete or team to maximise performance in the chosen sport, especially (from intermediate level upwards) at the most important competition of the period. Coaching science provides guidelines for effectively carrying out this task.

The many aspects of coaching include instruction in the technique of the sport, improving the physical fitness of the athletes, guiding the athletes' nutrition, developing tactics for effective application of the sports' techniques, preparing the athlete or team mentally, measuring training loads and recuperation means, providing technical, tactical and mental assistance during competition, and analysing past competitions to develop future objectives on the basis of this analysis. When preparing for tournaments to be held abroad, the coach may need to address many potential problems, for example, acclimatisation. In addition, coaches also try to identify talented youngsters and to assist them to identify and develop their opportunities in sport. Doing all this rationally and effectively requires knowledge provided by coaching science/theory.

The concept of coaching in modern terms relates to structured planning and systematic approaches that puts into practice types of coaching, contents and forms of coaching and the methods of implementation of coaching (exercises and training), aims of coaching whilst relating to scientific knowledge, practices and follow up.

Coaching is an open process for the beginner, advanced and elite athlete, for the student, the youngster and the elderly.

1.3. Body of Knowledge

Coaching science/theory brings together data from exercise physiology, biomechanics, sports psychology, sports medicine, sports sociology, kinanthropometry, motor learning, sport pedagogy, etc., as well as empirical data from coaching in all sports. From a coaching aspect, these data can be combined to form a multi-disciplinary, applicative discipline.

Coaching science as an interdisciplinary, integrative science based on the systematic collection and collation of significant data from coaching areas, sourced from competition, laboratory based experiments and the fields or play/participation. It is no coincidence that this area is called "systematic results".
The list of sources of knowledge is not conclusive and developments in various areas of human study may open up further sources for coaching to draw upon.

1.4. Methodology

Data "imported" from the various disciplines mentioned above have, of course, been formed under the methodology of the relevant science so they must then be checked, empirically and logically, for their relevance to coaching. A common pitfall occurs when data gained from general populations is used for coaching elite athletes, whose physical characteristics and mental attitude are entirely different.
Data gleaned from coaching practice depend, to a large extent, on the existence of orderly documentation of that practice. In most cases however, the data will not satisfy the usual criteria applied to scientific inquiries: the population would be too small for statistical significance; a control group may not be used as a comparison, so "double blind" studies are not tenable. This is why some experts in the field prefer the term "Coaching Theory" to "Coaching Science".

Interdisciplinary research into sport problems is the way of the future. Research will take into account the complex interactions between the mechanical and physiological systems, cognition and emotion, social groupings, as well as political and economic factors. These areas of research will have direct impact and practical consequences on talent identification, adherence to training and development programs, as well as prevention and treatment of sport injuries.

The scientific character of coaching theory will become more pronounced: the measurement of an athlete's state of training will become more accurate and reliable. The revolution in microelectronics, leading both to more powerful instruments and

much lower costs, enables much better objectivity in the process of training. Thus, coaches and scientists will develop a greater degree of precision in understanding exact training loads, which the coach will use to achieve more rational and effective coaching, and the scientist will gain a deeper understanding of the relation between cause and effect in training.

The massive involvement of the electronic media in virtually every sport – both amateur (sport-for-all), competitive and top-level – will probably entail an information specialist as part of the team which will include the athlete, the coach, sports scientists and sport medicine practitioners.

Coaching science, like all applicable sciences, amasses its knowledge through practical, supervised experiences using empirical science after follow up and/or using hypotheses that have been thoroughly assessed.

The focus is multi-disciplinary and simultaneous (application, behaviour, physiological profile, etc) whilst parallel to this is a collection of developing statistics in order to point to a working model, its influence and effectiveness over a period of time.

1.5. Relationship to Practice

Coaching science is the main subject in the process of coach education. In the past, we have had self-educated coaches (usually former athletes), who coached mainly by intuition. Sometimes they would employ aides to inform them of developments in coaching theory. This will no longer be sufficient - in fact, it already isn't. Just as the annual plan must be based on coaching theory, so too, the periodical adjustments of that plan and the day-to-day details for fulfilling the plan require understanding of the rationale – again, of coaching science/theory.

A central characteristic of coaching science and the theory of coaching is the connection between the field of work of the coach and the trainee (through training and relevant knowledge). From here stems the reason that the field is defined as a science, as a theory and as a methodology of directing the process and development of coaching with the understanding of the needs, demands and reality.

Supervision in the coaching process is done using valid tests and practical tools to assess the results and then to adapt them to the process of planned coaching.

Central to this assessment is the interaction between the coach and the trainee, where coaching is the field of activity in which relationships and abilities develop.

Top-level athletes (defined as realistic contenders for medals in Olympic Games and/or world championships) in leading countries, financed by the state and/or commercial sponsors, train under close to ideal conditions. The quest for higher levels of performance leads to innovations in the process of training and thus to deeper understanding of coaching and further development of coaching science/theory. While initially, such innovations may be beyond the scope available to intermediate, much less leisure-time athletes, in time, these innovations "percolate down" to all levels of sport training.

Examples of such innovations are:

- Altitude training to enhance aerobic endurance;
- ECG-style monitoring of heart rate during performance;
- Biofeedback in mental training;
- Measurement of lactic-acid concentration to determine optimal running/swimming speed in training and competition;
- Simulation camps as part of preparation for major competitions;
- The use of computer technology and of videos for analysis and instant playback of training sessions and competition;

- The understanding and application of the process of recovery from training.

There is increasing involvement of commercial firms in competitive sport, via sponsorship of special tournaments and outstanding athletes. At the same time, governments are decreasing their involvement. This is leading to a new competition timetable, which is less favourably oriented towards the athlete peaking at world championships and/or Olympic Games. This presents a challenge to coaching theory – to develop guidelines for sensible annual planning in this changing environment, which will facilitate proper preparation of the athlete for main events while ensuring that the athlete maintains both competitive fitness and long-term health and well-being.

1.6. Future Perspectives

Two developments seem to be shaping the road that coaching theory is going to take in the future: the revolution in microelectronics and the retreat of governments from direct involvement in the pursuit of achievement in sport, with commercial firms taking their place.

As electronic devices become both more sophisticated and more attainable (cheaper), much more use will be made of them to ensure objectivity of the process of training, on-line observation and analysis of the effects of training. Monitoring heart rate during exercise and feeding the observation into electronic data-processing instruments is already with us. It is only a question of time until non-invasive ways will be found to do the same with physiological markers of anaerobic exercise. Detailed measurements of the athlete's body (e.g. limbs and internal organs) would be fed into simulation programs, which would serve to personalise technique for optimal results.

The increasing involvement of commercial firms in competitive sport has been discussed in section 1.5 Relationship to Practice.

Basic questions are:

1. How do you create an optimal relationship between the above mentioned areas?
2. How can you direct the coaching session according to the results of the competition?
3. How does coaching influence or not influence the competition?
4. How do you reduce the gap between ability (potential) and current performance of the athlete/group?
5. How does indepth understanding of the ability to perform influence the aims of the coaching session in a decisive way?
6. How does high-tech activity (e.g. microelectronics) impact/influence the training process and athlete's potential?

In the near future, coaching systems in every field of activity will be closely monitored and documented over a period of time. This process will enable monitoring of the influence of the coaching systems (not just physical) and will check if the accompanying different scientific areas really have a direct and simultaneous impact.

2. Information Sources

2.1. Journals

Coaching science/theory is addressed in many journals dealing with sport science in general, and more specifically in journals devoted to sports coaching. Among the journals containing high numbers of articles are:

Coaching and Sports Science Journal (Rome: Italian Society of Sports Science, 1996-present);
Leistungssport (Elite Sport) (Mainz: Deutscher Sportbund, 1971-present, in German);
Teorija I Praktika Fizicheskoj Kul'tury (Theory and Practice of Physical Culture) (Moscow: Russian State Committee on Physical Culture and Tourism, Russian Academy of Physical Culture, 1925-present, in Russian);

Research Quarterly for Exercise and Sport (Reston, VA: American Association for Health, Physical Education, Recreation and Dance, 1929-present);
Biology of Sport (Warsaw: Institute of Sport, 1983-present);
Journal of Sports Sciences (London: E&FN Spon, 1982-present);
Theorie und Praxis der Körperkultur (Theory and Practice of Physical Culture) (Berlin: Sportverlag, 1951-1990, in German);
Theorie und Praxis Leistungssport (Theory and Practice of Elite Sport) (Berlin: Sportverlag, 1962-1990, in German);
Training und Wettkampf (Training and Competition) (Berlin: Sportverlag, 1962-1990, in German);

To these journals, one must add the various journals of the sciences contributing to coaching theory mentioned in section 1.2. Function above.

There are also more practice-oriented journals, such as:
Coaching Focus (Leeds: United Kingdom National Coaching Foundation, 1985-present);
Olympic Coach (Colorado Springs: United States Olympic Committee, 1991-present);
Sports Coach (Belconnen: Australian Coaching Council, Inc., 1977-present);
Sport Pulse (Limerick, Ireland: National Coaching and Training Centre, 1993-present);
Kinesiology (Zagreb, Croatia: University of Zagreb, 1971-present);
China Sport Coaches (Beijing, All-China Sports Federation, 1992-present).
Most specific sports have their own coaching journals, often published by their governing bodies, which of course also cover coaching science.

2.2. Reference Books, Encyclopaedias, etc.
The basic dictionary is:
Thiess, G., Schnabel, G. and Baumann, R. (Eds.). (1980). *Training von A bis Z*. Berlin: Sportverlag.
This has been updated by:
Schnabel, G., Harre, D., Krug, J. and Borde, A. (Eds.). (2003). *Trainingswissenschaft: Leistung - Training - Wettkampf.*München: Berlin: Sportverlag.
Thiess, G. (Ed.). (1987). *Leistungsfaktoren in Training und Wettkampf*. Berlin: Sportverlag.

A general sports-sciences oriented reference is:
Roethig, P. (Ed.) (1987). Dictionary of Sport Science (German-English-French). Schorndorf: Karl Hofmann.
Perhaps the most comprehensive book today is:
Harre, D. et al. (Eds). (1994). Trainingswissenschaft. Berlin: Sportverlag.
This is the 4th edition of the East German Coaching Science book, which was also translated into English (1982).

One of the “classic” books on the subject is:
Matveyev, L.P. (1965). *Problema Periodizatsii Sportivnoy Trenirovki (Problems of the Periodisation of Athletic Training)*. Moscow: Fizkultura I Sport.

The “state of the art” is presented in:
Platonov, V.N. (1997). *Obshchaja Teorija Podgotovki Sportsmenov v Olimpichkom Sporte (General Theory of Athletes’ Preparation in Olympic Sports)*. Kiev: Olimpiyskaja Literatura.
Good recent handbooks in English for coaches on General Coaching Science/ Theory include:
Ben-Melech, Y. (1998). *Training for Top Performance*. Cape Town: Gariep.
Crisfield, P., Cabral, P. and Carpenter, F. (Eds.). (1996). *The Successful Coach: Guidelines for Coaching Practice*. Headingley: National Coaching Foundation.
Pyke, F.S. (1991). *Better Coaching: Advanced Coach’s Manual.* Canberra: Australian Coaching Council.

Carmeli, E., Wertheim, M. and Werner, S. (2000). *Geriatric Rehabilitation Model as a Controlled Training Process*. Physiotherapy, 4(1).

Carmeli,E. and Wertheim, M. (2001). Handverletzungen bei Jugendlichen und erwachsenen Sportklettern. *Deutsche Zeitschrift Für Sportmedizin*, 52(10) Germany.

Wertheim, M. (2000). Die Ausbildung des Sportlehrers zum Trainer im Wettkampfsport unter besonderer Berücksichtigung der Integration der Trainingswissenschaft. *Leistungsport* (2). Germany.

2.3. Book Series

American Coaching Effectiveness Program. (Champaign, Ill.: Leisure Press 1984-94, Leisure Kinetics 1989-92).

National Coaching Certification Program.(Various places, Various publishers).

Studienbrief der Trainerakademie Köln (Study Letters of the Coaching Academy in Cologne). Schorndorf: Karl Hofmann 1988-present.

2.4. Proceedings

Tenenbaum, G. and Eiger, D. (Eds.). (1991). *Coach Education: Proceedings of the Maccabiah-Wingate International Congress*. Netanya: E. Gil.

Tenenbaum, G. and Raz-Liebermann, T. (Eds.). (1993). *Proceedings: 2nd Maccabiah- Wingate International Congress on Sport and Coaching Sciences.* Netanya: Wingate Institute.

Coach Education - 1st International Coach Education Summit July 1995. Leeds U.K. National Coaching Foundation.

Lidor, R., Eldar, E. and Harari, I. (Eds.). *Proceedings of the 1995 AIESEP Congress: Bridging the Gaps between Disciplines, Curriculum and Instruction*. Netanya: Wingate Institute, Zinman College of PE and Sports Sciences.

Coach Education towards the 21st Century: 2nd International Coach Education Summit: September 21-24, 1997. Netanya, Israel: Wingate Institute – Nat Holman School for Coaches and Instructors.

Walkuski, J.J., Wright, S.C. and San, S.T.K. (Eds.). (1997). *AESEP Singapore 1997 World Conference on Teaching, Coaching and Fitness Needs in Physical Education and the Sports Sciences: Proceedings*. Singapore: School of Physical Education, Nanyang Technological University.

Coaching New Zealand et al. (1996). *Partners in Performance National Conference 11-13 October, 1996 - Proceedings of the combined national conferences of Sports Medicine New Zealand and Sport Science New Zealand.*

Canadian Olympic Association: Coaching Association of Canada 1991: Ottawa: Fitness and Amateur Sport.

11th Annual Conference on Counselling Athletes (1994). *Assisting today's athletes toward peak performance*. Springfield: Springfield College.

1994 the year of the coach (1994). National Coaching Conference proceedings, National Convention Centre, Canberra, Australian Sports Commission, p. 10-12.

Marconnet, P. et al. (Eds.). (1996). *First annual congress, frontiers in sport science, the European perspective, May 28-31: Book of abstracts*. Nice: European College of Sport Science.

Fitzgerald, A. (Ed.). (1990). *Olympic education: breaking ground for the 21st century: proceedings of the USOA XIII Evergreen State College 1989*. Colorado Springs: United States Olympic Committee Education Council.

UK sport: partners in performance. (1993). *The contribution of sport science, sports medicine and coaching to performance and excellence*. Book of abstracts, s.l., Sports Council.

For excellence. A Symposium on Canadian High Performance Sport (1990). February 12, 13, 14, 1989: proceedings, February 1990. Ottawa: *Fitness and Amateur Sport*.

Coaching Association of Canada: Association canadienne des entraineurs, Gloucester, Ontario, 1992, 1 binder.

Developing the young athlete: 3rd Elite Coaches Seminar, Australian Institute of Sport, Canberra, 29 November - 2 December 1990. Canberra: Australia Coaching Council.

Beyond Barcelona: (proceedings of the) 4th Elite Coaches Seminar, Australian Institute of Sport, Canberra 27 to 29 November 1992, Canberra, Australian Coaching Council, 1992.

2.5. Databases

Sport Discus (Sport Information Resource Center, Canada, multilingual).
Atlantes(Instituto Andaluz del Deporto, Spain, in Spanish).
Heracles (Institut National du Sport et de l'Education Physique, France, in French).
Spolit (Bundesinstitut für Sportwissenschaft, Germany, in German).

2.6. Internet Sources

Coaching & Officiating unit of the Australian Sports Commission (ASC)
www.ausport.gov.au/participating/coaches
Coaches Corner (Gatorade Sports Science Institute, USA)
www.gssiweb.com
Coaching Association of Canada
www.coach.ca/
Sports Coach (B. Mackenzie, United Kingdom)
www.brianmac.demon.co.uk/
Wingate Institute for Physical Education & Sport (Israel)
www.wingate.org.il
United States Olympic Committee – Olympic Coach
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3. Organisational Network

3.1. International Level

The International Council for Coach Education (ICCE), represents the various bodies concerned with education of coaches and application of Coach Science/Theory in daily work all over the world. It was founded in 1997. The objectives of the ICCE are to promote Sport Coaching in general, and as a profession in particular, by various means, specifically, by "promoting and utilising research in the field of training and competition", "exchanging knowledge in the field of coaching", "disseminating information about curricula, qualifying standards etc.", "professional publication in the field of coaching education" (ICCE Objectives). In 2002, 21 countries were represented in ICCE, which holds conferences every second year (one year before the summer and winter Olympic Games, in the city in which the Games are to be held).

Other international organisations concerned with sports and physical education, such as AIESEP (Association Internationale des Ecoles Supérieures d'Education Physique), FIEP (Fédération Internationale d'Education Physique), ICHPER-SD (International Council for Health, Physical Education, Recreation, Sport and Dance) and the International Olympic Committee (through the aid it provides by way of the Olympic Solidarity program) all use and promote Coaching Science/Theory as a secondary part of their activities.
The Governing Bodies (International Federations) of the various sports do the same with regard to sports-specific Coaching Science/Theory.

3.2. Regional Level

The European Union has taken the initiative to design a 5-tier scheme of coaching levels. Many other countries, including Canada have adopted a similar scheme for their National Coaching Certification Program. This scheme provides a framework for the use of Coaching Science/Theory, from the rudimentary stage of the Level 1 Coach up to the academic-degree level of the Level 5 Coach, who utilises the most sophisticated and advanced facets of Coaching Science.

3.3. National Level

Several countries teach, advance and promote Coaching Science/Theory in their national sports centres, in which both coach education and top-level sport training is centralised. Examples are:

- Australia, through the Australian Coaching Council;
- Canada, through the Coaching Association of Canada;
- China, in its Coaching Department of the All-China Sports Federation;
- France, in its INSEP (Institut National du Sport et Education Physique);
- Germany, in its Cologne association of the Trainerakademie and Deutsche Sporthochschule and in - Leipzig (Leipzig University and the Institut für Angewandte Trainingswissenschaft);
- Great Britain, through the National Coaching Foundation;
- Hungary, in the Budapest University of Physical Education;
- Israel, in the Nat Holman School for Coaches and Instructors at the Wingate Institute for Physical Education and Sport;
- Switzerland, in its Magglingen Sports Centre in Biel; and
- United States, through its coaching leadership of the Olympic Training Center at Colorado Springs.

In addition, countries are developing Coaching Science/Theory through their Sport Governing Bodies, University Physical Education and Sport Colleges, Sport Institutes etc.

3.4. Specialised Centres

See details under section 3.3 National Level.

3.5. Specialised International Degree Programmes

Several universities in the former Eastern Bloc e.g. Kiev, Budapest and Leipzig, educate coaches in a 4-year academic program which includes a thorough grounding in Coaching Science/Theory.

The Level 5 coaching program of the European Union is similar and is carried out in accredited universities. It takes 4 full years and includes 2400 study hours, half of which are general sports science studies and the other half sports-specific studies. In addition, the students must have 2 years of practical coaching experience.

4. Appendix Material

4.1. Terminology

Most of the terminology of Coaching Science/Theory has been developed in the countries of the former Eastern Bloc. Today, there is an overall consensus on the terminology, although some inconsistencies and illogicalities remain. As examples, use of the terms “mesocycle” and “macrocycle” differ between different authors; “training means” is sometimes defined narrowly but sometimes very broadly; “training methods” sometimes refers to the spectrum “continuous-interval-repetition” only, while on other occasions it will include the “pyramid” method, “whole” and “part” technical learning methods, etc. In English, “strength” is used in places where “force” would be appropriate, while in German, “Leistung” is used for “power”, “achievement” and “performance”. The difference between “power”, “speed-strength”, “strength-speed” and “explosive strength” is often unclear. But these inconsistencies and illogicalities are minor flaws and usually the context makes the meaning abundantly clear.

4.2. Position Statement

“Coaching Science is a branch of Sports Science, which deals with the theoretical foundations and methodological forming of athletic training, subject to the aim of achieving physical perfection, developing athletic performance as well as success in athletic competition.” (Schnabel et al. 1986).

4.3. Varia

Not applicable.

4.4. Free Statement

Sports Coaching Science in general and the education of coaches in particular, are currently helping in the creation of a new profession: Sports coaching, which is coming of age as a fully-fledged profession. As the public today has more leisure time than previously, there is a need to use this time effectively and sensibly. There is a demand of parents, teachers, physicians and the public at large, that care be taken of children's health and well-being, and that they may be enabled to grow and develop according to their gifts and preferences. This necessitates, much more than in the past, that sports coaching be based on moral, scientific and professional foundations and that those engaged in coaching be educated professionally, even academically, in the opinion of some people, just as members of other professions are prepared for theirs.

With rapid developments in information technology, both of software and hardware, coaching education will increasingly turn to various forms of "e-learning" in order to, on one hand, reduce the expenses incurred in coach education and, on the other hand, to provide wider access of students of coaching to the world's leading authorities on the subject. These new methods of teaching will also serve to disseminate more rapidly and more widely the most recent advances in coaching know-how.

4.5. Update

New Tendencies in Training Science for Children

1. Scientific focus on and ways of research in children's training.
   Different structures for motor coordination
   Ability for coordination under pressure of time , place and complex
   Ability for coordination under pressure of time, place, complex and with the ability of control and adaptation as a process in training.
2. Training, planning in combination with computer sciences, long term planning.
3. Research on competition: From analysing the performance to simulating the successful strategy.
4. The role of intellectual processes increasing as a result of the new tendencies.
5. New ways in the education of coaches and special instructors for children.

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