CONTENT STRAND: MOVEMENT SKILL AND PERFORMANCE

TOPIC 4
Movement skills, strategies and tactics

4.1 Overview

4.1.1 Introduction

There is a strong link between proficiency of movement and quality of performance. The fundamental skills learnt as a child form the basis of the more complex skills needed to complete specialised activities that are specific to a sport or recreational pursuit. Successful performers have common characteristics in their skill execution; their movement is smooth flowing and performance consistent. There are different methods used to evaluate performance, including subjective observation and criteria checklists. The type of skill performed and the environment in which it is performed will determine the most appropriate method of evaluation. Feedback using performance measures, practice and a knowledge of biomechanics can help build skills and improve your technique.

**Resources**
- eLesson: Movement skills, strategies and tactics (eles-2966)
- Digital doc: Key terms glossary (doc-29292)

**ESSENTIAL QUESTION**
Why is it important to identify and measure the proficiency of movement in athletic performance?

**SYLLABUS OUTCOMES**

A student:
- adapts and improvises movement skills to perform creative movement across a range of dynamic physical activity contexts (PD5-4)
- appraises and justifies choices of actions when solving complex movement challenges (PD5-5)
- refines and applies movement skills and concepts to compose and perform innovative movement sequences. (PD5-11)
4.2 Fundamental movement skills

As you grow and develop, with practice, you build and refine your movement performance. This increase in skill proficiency is observable in the physical characteristics of the skill and the quality of your performance.

4.2.1 Building on basic skills

All advanced skills and techniques in sport evolve from the fundamental skills developed during childhood and adolescence.

Fundamental movement skills are basic motor skills, which are foundation skills aiding development of movement patterns and more complex skills, known as sport-specific skills. Children learn to crawl, walk, run, skip, throw, catch, bounce, hit and jump. These basic skills lead to the more specialised skills required in games, dance, gymnastics and other sporting and recreational pursuits.

Use the Basic skills worksheet in the Resources tab to link basic skills to more complicated ones.

4.2.2 Proficiency and quality of movement

The link between proficiency of movement (or skill proficiency) and the quality of performance is very strong. The characteristics of proficient movement are:

• certainty of achieving the movement goal
• minimising energy expenditure during the performance
• minimising the movement or performance time (in activities where speed is essential).

![Diagram showing the relationship between fundamental motor skills, rudimentary movement skills, infant reflexes and reactions, and sport-specific skills.]

**Javelin throw, baseball pitch, badminton clear, tennis serve, gridiron pass, overhand volleyball serve**

**Golf swing, hockey drive, baseball swing, forehand drive, cut shot**

**Overhand throw**

**Two-hand side-arm strike**

**Sport-specific skills**

**Fundamental motor skills**

**Rudimentary movement skills**

**Infant reflexes and reactions**
4.2.3 Specialised sporting skills
Specialised sporting skills are found in a wide variety of games and sports played throughout the world. Moving from the fundamental skills to these more specialised skills involves a process similar to assembling building blocks. The fundamental skills constitute the foundations upon which more specialised skills are developed. For example, the catch, strike and overarm throw form the basis of the more specialised sport-specific skills employed in cricket, baseball and softball.

4.2.4 Judgement of movement
When we view movement performances, we often make judgements about them. When judgements are based on our feelings or impressions, they are subjective judgements. Such evaluation is fine when we are spectators; however, subjective judgements can have a low degree of accuracy. To improve the quality of the judgement, a good understanding of what constitutes proficiency in terms of the movement performance is required. This can be done by using consistent methods, techniques or tools for appraising the proficiency of the movement. This makes the judgement more objective in nature, which increases the accuracy of the feedback. These are called objective judgements.

4.2.5 Maximum certainty of goal achievement
One quality of skill proficiency is movement certainty. To be ‘skilled’ implies that the individual can achieve the movement or performance goal consistently and with limited variation in movement. Individuals who can demonstrate these characteristics are considered to have attained mastery.
**DID YOU KNOW?**
Elite athletes often have set routines leading up to the performance of a skill. The routine is always the same; this leads to consistency in performance, assists in psychological preparation and results in achievement of the performance goal or outcome. This is observable in skills such as the golf swing or tennis serve, although these need to be modified at times due to changes in the external environment. This includes movement patterns of an opponent or changes in the weather (such as hitting into a headwind).

### 4.2.6 Minimum energy expenditure
Spending less energy when performing repeated actions limits fatigue and enhances performance. Mastery of skill technique eliminates unnecessary movements, making individuals more efficient; this quality is often observable — skilled performers often appear to be performing the activity easily, looking coordinated and requiring less energy with each skill execution.

### 4.2.7 Minimum movement time
Skilled performers in many activities execute their movements quickly and efficiently. We often hear of skilled performers seeming to have ‘more time’ in which to perform the skills of their chosen sport. This is often a function of their ability to perform movements in a reduced timeframe.

Elite gymnasts perform their routines with a minimum of unwanted or unnecessary energy expenditure. Skilled cricketers like Usman Khawaja seem to have ‘plenty of time’ to play their shots — a sign of a skilled performer.

### 4.2 Activities
**A+ sport**
1. Use the Skilled performance weblinks in the Resources tab to watch several skilled sporting performances. Evaluate them in terms of the characteristics of proficient movement.
(a) Describe how each performance appeared to you. Note the rhythm, pace and ease of movement.
(b) Did the performers achieve their goals?
(c) What was the goal in each case?
(d) Did the performances minimise energy expenditure?
(e) Were the performances 'efficient' in nature?
(f) Contrast the performance of a beginner to that of the more experienced athletes.

Be proactive

2. Teachers often complain about a ‘crowded curriculum’. Taking this into consideration, argue a case for more sport and physical activity in schools at a primary school level. Your argument may include some of the following points:
• the link between basic skills developed during childhood and sophisticated skills required to participate in sport and other recreational activities during adolescence and adulthood
• the importance of participation in sport at the primary school level for social development
• the importance for children to develop proficiency in the fundamental movement skills.

4.2 Check and challenge

Explain
1. What is meant by the statement ‘skilled performers always seem to have more time to perform the skills’? Why is this statement often true?

Elaborate
2. Refer to the ‘Fundamental movement skills instruction and its effect on the performance of sport-specific skills’ diagram in section 4.2.2 and describe in your own words what it illustrates. Provide an example, other than the ones given in the diagram, that illustrates how basic skills can be transferred to more specialised skills.

Evaluate
3. Think of ten sports and evaluate what level of skill you have attained in each of them.

4.3 Appraisal of movement proficiency

Analysing or measuring proficiency of movement is used to provide feedback to individuals as well as give rankings or scores to competitors. The type of analysis used will be dictated by the nature of the task and the context in which it is performed.

4.3.1 Measuring proficiency
Movement skills can be measured for proficiency by assessing the quality, efficiency and outcome of the performance.
Movement proficiency can be analysed and measured in a number of ways. These include:
- observing the performance live
- judging or scoring the performance
- measuring the outcome of the performance
- comparing the outcome with the percentile charts
- data collection and movement analysis
- criteria checklists
- skill tests.

Not all these methods can be applied to all types of movements or skills. In this subtopic, each method will be described, and an opportunity to use each method for measuring performance will be provided.

Use the Explaining gymnastics judging and Kids gymnastics weblinks in the Resources tab to watch some performances. Which method from those listed above would you use to appraise the performances?

4.3.2 Appraising movement proficiency

It is possible to assess movement or skill proficiency in terms of both its process (for example, the quality and efficiency with which the elements of the skill are performed) and its outcome (for example, a result, such as a goal, or some form of measurement, such as a distance achieved).

To appraise movement proficiency, some method, technique or tool for assessing the level of performance is necessary. These are called performance measures. However, before applying performance measures, a number of factors need to be considered. These factors can affect our judgement of the movement performance, and include:
- individual characteristics of the performer, such as age, size, body type, fitness level and experience
- level of performance, for example, novice or elite, club, state or national competition
- performance context, for example, practice as opposed to a game situation
- environmental conditions such as weather, or other opponents.

We also need to consider who determines the criteria for appraisal and who sets the standards upon which to assess the movement. In many national and international sporting competitions (such as gymnastics and figure skating), movement requirements, categories, deductions and degrees of difficulty are all determined by sporting bodies and federations, who use experts to determine what constitutes a skilled performance.
It is also important to realise that, while most athletes will largely adhere to the principles that underpin proper technique, some will modify their style to suit themselves. This explains why there are many variations of the accepted technique. For this reason, it is important to determine whether any particular variation is basically sound or inherently weak, as distinct from labelling anything as ‘right’ or ‘wrong’, or attempting to get every player to adhere to an identical technique.

4.3.3 Performance measures

The appraisal of performance can be a very complex task; therefore, a range of performance measures are frequently used.

Observation

Observation of performance can be used to appraise both the level of skill proficiency during the performance and the outcome or result of the performance. Observation can be seen as a continuum from ‘highly objective’ to ‘highly subjective’.

Performance criteria, checklists, rubrics and rating scales

Observations of performance can be made more objective by focusing on the specific criteria, qualities and/or desirable aspects of a performance, and assigning them categories (for example, excellent, good, average, fair, poor) and/or rating scales (for example, 5, 4, 3, 2, 1). To develop criteria to be used in the appraisal of movement performance, follow the three steps below:

1. Specify the nature of the movement or skill — ascertain exactly what it is you want to appraise.
2. Establish the performance criteria you want to use — determine and list the particular aspects of the movement or skill that you will be appraising and making judgements about.
3. Practise applying the criteria — to develop the analytical skill to appraise movement performance, it is necessary to practise.

Checklists and rubrics are usually developed from performance criteria. If a particular part of the movement or skill is performed correctly, a tick or rating is given to it. This information can be used to help the performer rectify faults or errors and thereby improve his or her level of skill proficiency. Checklists, rubrics and rating scales can allow for self-appraisal, peer appraisal, and teacher or coach appraisal of performance.

Skill tests and performance achievements

Skill tests provide an indication of the outcome rather than the skill or movement process. There are many tests used to measure skill performance. An example is the vertical jump test, which is used to assess leg power and jumping technique. It is possible to utilise a range of performance achievements to measure aspects of a movement performance. These measures can include speed, distance, time, height, weight and accuracy, and are often expressed numerically. For example, ‘Lachlan ran 13.5 seconds in the 100-metre sprint’.
Norm- and criterion-referenced standards and percentile ranks

Norm-referenced standards (or normative scales) allow an individual’s score or result to be compared with the performance of a representative group (usually a reference group, such as a nationwide sample of students of similar age and gender) in the same task or test and are competitive.

Criterion-referenced standards interpret an individual’s score or result compared to others of similar age or gender, etc. The focus is normally achieving mastery or competency rather than a ranking.

Percentile ranking is common in norm-referenced standards. Percentiles indicate the percentages of a reference group that score above or below a given score on the scale. For example, ‘Siobhan achieved a score that put her at the 85th percentile’. This indicates that she has scored higher than 84 per cent of those taking the test, in other words, in the top 15 per cent of the compared population.

Statistical information

Statistical information obtained from an activity analysis (or games analysis) can also be used to appraise performance. The most common statistical data obtained from games analysis includes:

• possession skills, for example, passes received in rugby
• disposal skills, for example, kicks and handballs, including the effectiveness or otherwise of these in Australian Rules football
• successful and unsuccessful scoring attempts
• movement patterns that indicate the type of movement such as running, side stepping, jogging and shuffling backwards
• GPS data that indicates time spent in different speed zones. This gives the coach and athlete an understanding of time spent at different intensities.

4.3.4 Performance appraisal of selected motor skills

In this section, we consider the appraisal of movement proficiency in a number of motor skills, ranging from fundamental movement skills to more specific sporting skills. In each case, use the video eLessons in the Resources tab to access a criteria checklist, rubric or table as the means of appraising the movement proficiency related to the particular skill.

The NSW Department of Education produce a guide to the development of a fundamental motor skills program for children in primary school. The Fundamental Movement Skills in Action and accompanying instructional teaching cards provide a list of skill components for each of the core skills. These provide an excellent template for the development of similar skill components for other, more complex, sports-specific skills.

Skill components for the catch, overarm throw, and kick are listed below.

Skill components for the catch

1. Eyes are focused on the object throughout the catch
2. Preparatory position, with elbows bent and hands in front of body
3. Hands move to meet the object
4. Hands and fingers positioned correctly to catch the object
5. Catch and control the object with hands only
6. Elbows bend to absorb the force of the object
Skill components for the overarm throw
1. Eyes are focused on the target throughout the throw
2. Stand side-on to the target
3. Throwing arm nearly straightened behind the body
4. Step towards the target with foot opposite throwing arm during the throw
5. Hips then shoulders rotate forward during the throw
6. Throwing arm follows through, down and across the body

Skill components for the kick
1. Eyes are focused on the ball throughout the kick
2. Forward and sideward swing of the arm opposite the kicking leg
3. Non-kicking foot is placed beside the ball
4. Bend the knee of the kicking leg during the backswing, at least 90 degrees
5. Top of foot or instep makes contact with ball
6. Follow through of kicking leg towards target area

Other specific sporting skills
Skill components for the golf swing, javelin throw, drop punt kick and soccer throw-in can be accessed by using the video eLessons in the Resources tab.

4.3.5 Qualitative analysis of human movement
Observing, analysing and appraising human movement performance through the use of performance criteria and checklists is a form of qualitative analysis. Coaches and teachers need to be skilled in qualitative analysis to be able to provide the most appropriate interventions for improving the performance. Qualitative analysis usually involves four key phases.

The preparation phase involves the coach or teacher determining the goal of the analysis as well as identifying key components of the performance that will be critiqued. They must also familiarise themselves with
common errors that performers exhibit. They gather this information from scientific research, expert opinion and personal experience.

Observation involves watching the performance live or recording then watching the performance. Observers often break down the movement into three phases: preparation phase, execution phase and follow-through phase. Movement phases can be further divided into key elements. Key elements are distinct actions that join to make up a phase. For example, in the execution phase of a golf drive, the key elements are the weight shift, hip rotation, head position, and arm and club extension. Phases and elements samples can be seen in the skill criteria and checklists previously described in this topic.

The third aspect of qualitative analysis involves the evaluation of the desirable (strengths) and undesirable (weaknesses) aspects of the movement or skill performance.

The final task in qualitative analysis is error correction. This involves providing feedback, usually while practising, and could be verbal, through identification of key areas of focus, or visual, through demonstration. It also involves creating activities or strategies that will lead to improved performance by addressing deficiencies in skill execution.

DID YOU KNOW?
Skills can only improve if the athlete is given specific feedback about their performance. Elite athletes and coaches are dependent on teams of people who gather data from the performance of the individual, the team and opponents. This data is used to fine tune and, at times, change an athlete’s technique, the team tactics, or match up players to effectively counteract opposition strengths.

4.3.6 Video analysis software
An important tool in qualitative analysis is the use of video analysis software. This allows for the observation of greater movement detail, the unlimited capacity to replay and observe the movement over again, as well as split-screen comparisons and overlays of performance. Some software products allow the placement of graphics and drawings on the video to illustrate key features and aspects of the performance.

Recent advances in integrating video and computer technologies have made many video analysis software programs affordable. Several companies have programs and packages especially designed for use by teachers and students. Two examples are Webbsoft Technologies’ ‘Swinger’ software and Dartfish’s ‘DartTrainer’ software. There is also a range of applications (apps) that can be used on digital platforms such as iPads and Android devices.

4.3 Activities
Appraisal
1. Suggest which method of appraisal (subjective or objective) is best suited to each of the performances below and explain your reasoning.
   - Tower diving
   - Tennis rally
   - Hockey penalty stroke
   - 100-metre sprint
Measuring performance and skill proficiency

2. Test yourself and a partner on the following skill proficiency tests. Use the Performance and proficiency worksheet in the Resources tab to record your results and those of your partner. Alternatively, draw up a recording table of your own. Note that the following basketball tests can easily be adapted to other sports, such as netball or soccer.

Basketball goal shooting:
(a) Set out eight cone markers around the vicinity of the key, as shown.
(b) Begin at cone 1 and have three shots at goal. Count the number of successful shots and then record this score.
(c) Proceed to the rest of the marker cones in sequence and repeat the three shots at goal. Record the number of successful attempts at each cone and the number of successful attempts in total.
(d) Additionally, or alternatively, you can begin at cone 1 and attempt to shoot a goal. Continue taking shots until you are successful and then move on to the next cone and repeat. Count and record the total number of shots it takes you to score a goal successfully at each cone marker and in total.

Basketball free throw shooting:
(a) Have 10 shots at goal from the free throw line.
(b) Repeat three times, recording the number of successful shots in each set of 10 shots, as well as the total number that were successful.

Basketball ball handling and dribbling:
(c) While dribbling the ball, run in a figure-eight shape twice around two marker cones placed 10 metres apart. Record the time taken to complete the task.
(d) Repeat, but this time, run and dribble in the opposite direction around the cones. Record the time taken to complete the task.

Comparing tests
3. (a) Compile the whole class’s results from activity 2 and calculate the group’s average scores as a benchmark proficiency in each test.
(b) Based on the benchmark proficiency score for each test, how did you perform?
(c) Which skill did you perform best?
(d) Which skill do you need to work on the most?
(e) Using these results, collaborate with a peer to set some personal goals.

Set the test
4. Design three other simple skill proficiency tests that could be used in a sport of your choice. Be prepared to explain these tests to the rest of the class.

Performance appraisal by activity analysis
5. (a) In groups of three, undertake an activity analysis of a player engaged in a sport of your choice. This can be done by observing your class engaged in playing sport, by observing a match played locally, by attending an elite level match or by viewing a video of a match.
(b) Record your data using the sample tables provided in the Activity analysis worksheet in the Resources tab.
Performance appraisal of selected motor skills

6. Over a period of three to five sessions, teach one of the fundamental motor skills to a small group of younger children, and assess their motor skill proficiency by the end of the instructional period. If they are showing strong skill execution, consider making some variations to the skill; for example, increasing the space over which the ball is thrown or using a different size ball. Use the Fundamental appraisal worksheet in the Resources tab to help you.

Using technology for feedback purposes

7. Research the use of technology in sport and how it can help an athlete improve performance via feedback. Come up with two types of technological tools that can help provide athletes and their coaches with appropriate feedback to modify and improve performance. This may include video analysis, computer software or use of ‘applications’ via smartphones. Discuss the advantages and disadvantages of the two tools selected. Finally, decide on the one that would be most appropriate for you. Justify your response.

4.3 Check and challenge

Explain
1. Explain why athletes seek feedback from a teacher or coach who will help them improve their technique and performance.

Elaborate
2. Discuss the merit of using performance criteria to evaluate a skill in comparison to using only the outcome of the performance as a measure of success.

Evaluate
3. How should your movement proficiency be assessed in a school situation? Think about which of the methods of assessing movement proficiency is the most practical in a school situation and why. Which method of assessing movement proficiency is most accurate? Explain your answer.

4.4 Skill acquisition

Skill acquisition is the process by which you learn motor skills. Through the learning process, you will demonstrate different characteristics, depending on which stage of progression you are in. Skills themselves are characterised according to the environment and their complexity. This assists coaches or teachers in creating the most appropriate learning environment.

4.4.1 The stages of skill learning and types of skills

When learning a new skill, you need time and practice to develop distinct stages of progression: the cognitive stage, the associative stage and the autonomous stage. Skills may be grouped according to their characteristics,
or how they are performed. They may be either open or closed, depending on the environment and may be
discrete, serial or continuous, depending on their complexity.

Skill acquisition is a staged process and can be achieved rapidly or more slowly, depending on the type of
skill, the complexity of the task, the quality of feedback, amount of practice time and ability of the performer.
A teacher or coach is vital to learning new skills as they provide the activities, feedback and instructions that
enable the skill to be mastered. In this subtopic, we will look at all the elements of skill acquisition.

Can you remember when you first learned to ride a bike? In pairs, discuss the stages of learning for
this skill.

How does a beginner become an athlete?

4.4.2 Skill acquisition
Skill is the learned ability to bring about predetermined results with maximum certainty, often with minimum
outlay of time or energy or both.

4.4.3 Stages of skill learning
Whenever an individual is learning a new skill, the teacher or coach should understand the stages of learning
and be able to recognise the characteristics of each stage.

The three stages of learning

Cognitive stage
(or beginner stage)  Associative stage
(or practice stage)  Autonomous stage
(or automatic stage)

Cognitive stage
Individuals who are at the cognitive stage of skill learning think carefully about the skill before they execute
it. Their movement is often jerky and lacking in coordination. Learners in this stage make frequent errors and
are unable to detect their errors; they require feedback from coaches or teachers to improve.
These learners need minimal verbal information; two or three key points to focus on will suffice or they will become overwhelmed. A visual demonstration is a powerful teaching tool.

A coach should demonstrate the skill so the player can visualise it and then have the player practise it. After allowing the person to practise the skill for a while, the coach should point out their errors, re-emphasise and demonstrate the key points and then have the learner practise the skill again.

**Associative stage**

During the **associative stage**, the individual is beginning to get the feel of the movement and fewer errors are made. Demonstrations and feedback in this stage can help individuals to gain confidence and refine their skills. It is important to note that the time spent in this stage will depend on a number of factors, such as the complexity of the skill, the motivation of the individual, the ability of the coach to detect errors and to provide accurate feedback, and the individual’s abilities and past experiences. Some people may never progress beyond this stage; it requires time, commitment and persistence to progress.

**Autonomous stage**

In the **autonomous stage**, the individual is able to complete the skill with little conscious effort. Smooth-flowing movement is observed and the individual will be able to detect and correct their errors. The skill could be sped up or slowed down, depending on the requirements of the situation. Other information can now be taken in, such as the opponent’s moves, the weather conditions and other external factors that may affect the skill. At this stage an athlete can experiment with slight technique modifications, such as application of different degrees of force or spin.

**DID YOU KNOW?**

Most people are able to move to the associative stage of skill learning quite quickly; however, entering the autonomous stage may take months or years of practice, and some people may never be able to progress to the autonomous stage. The younger a person is when developing a skill, the more likely it is they will progress through to the autonomous stage.

**4.4.4 Classification of skills**

The teacher or coach should be knowledgeable about the different types or classifications of motor skills, as these have implications in terms of skill acquisition and practice. A common classification is to consider the environment and categorise skills on an open and closed continuum.
Closed skills

Closed skills are performed in an environment that is stable, predictable and allows performers to plan their movements in advance. Performers executing a closed skill are in full control of the timing or speed of the skill; that is, it is internally paced. Examples of closed skills are a golf swing, a gymnastics routine, taking a free throw in basketball and swimming in a pool. Closed skills can usually be mastered more easily because the skill performance is the sole focus point and other variables do not influence how the skill is executed.

Open skills

An open skill is a skill performed in an environment that is variable and unpredictable. Open skills are usually externally paced and performed in a constantly changing environment. Performers therefore need to be aware of these changes and adjust their movements to suit. Examples of open skills are batting in cricket, softball or baseball, and playing team sports that have opposition, such as football, netball and hockey.

Open skills are often more difficult to perform, as more decisions need to be made before executing the skill. For example, receiving a pass in netball requires you to make decisions on where to move to receive the ball, at what height and speed the ball will come at you, where your opponent will be and what you will do when you catch the ball. When learning skills, it may be possible to ‘close’ the skill down, then gradually ‘open’ the skill over time. Using netball as an example, passing and catching the ball can be done in a closed environment by passing it to a stationary player. When that is mastered, you can open the skill by receiving the ball on the move, then adding passive opposition, followed by full opposition, a lead-up game and, finally, a full game.
Discrete, serial and continuous skills

Another method of classifying skills is according to the way in which the timing of the movements is organised. Skills classified in this way are referred to as discrete, serial or continuous skills.

Discrete skills involve movements of brief duration, and they have a distinct beginning and end. Examples include throwing and kicking a ball.

Sometimes, discrete skills are linked to form more complicated actions. These types of skills are classified as serial skills. The duration of serial skills is longer, and each individual movement in the series has a definite beginning and end. However, the order of the elements that make up the total skill is often crucial to performance success. Performing a tumbling run in gymnastics is an example. Such skills are best acquired by breaking the skill down into its component parts and then linking them back together.

Continuous skills have no distinct beginning or end. These skills or movements are often repetitive or rhythmic in nature and may continue for several minutes. Examples include running, cycling and swimming.

A final way of categorising skills is in relation to the degree of muscle force required for successful outcomes. At one end of the spectrum, some skills require the involvement of all muscles, activated by strong and continuous messages sent via the nervous system. These movements are referred to as gross motor skills. Examples include lifting a heavy weight and throwing a javelin. Conversely, some sports require the use of few muscles, activated by a small number of nervous impulses. These are referred to as fine motor skills. Examples in sport of fine motor skills include darts, billiards, shooting and archery.

### Skills classification

- **Closed**
  - Stable and predictable environment
  - Internally paced or timed
  - **Examples:**
    - Golf swing
    - A gymnastics routine, taking a free throw in basketball

- **Open**
  - Variable and unpredictable environment
  - Externally paced
  - **Examples:**
    - Batting in cricket and team sports that have opposition

- **Discrete**
  - Movements of brief duration
  - Distinct beginning and end
  - **Examples:**
    - Throwing and kicking

- **Serial**
  - Combination of several discrete skills to form a more complicated action
  - **Examples:**
    - Performing a gymnastics routine

- **Continuous**
  - No distinct beginning or end
  - Rhythmic flowing movements
  - **Examples:**
    - Running, cycling and swimming

### 4.4 Activities

The open–closed continuum

**Equipment:** One basketball per group of three

1. (a) Set up using a quarter of a basketball court, one player with the ball at the end of the quarter and one in the middle, as shown in the diagram on the right. The third player is initially an observer.
   The player with the ball performs the serial skill sequence of bouncing on the spot then throwing to the mid-court player. This is a closed skill. Follow each of the steps below to progressively open up the skill.

<table>
<thead>
<tr>
<th>X Player 1</th>
<th>X Player 2</th>
<th>X Player 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key</td>
<td>Throw</td>
<td>Walk/run</td>
</tr>
</tbody>
</table>

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• Dribble the ball while walking, throw the ball to the middle player then receive the ball while stationary.
• Dribble while running, throw the ball to the middle player then receive the ball while running.
• Add in the third player as a stationary defender, then as an active defender.

(b) Consider three different changes you could make to the sequence to make it even more challenging.
(c) Discuss as a group how the variables opened up the skill (movement context) and made it more challenging to perform.

Summarise
2. The stages of skill learning are clearly described in this subtopic. Complete the table below to summarise the three stages of skill acquisition.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
<th>Examples in sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomous</td>
<td></td>
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</tbody>
</table>

Continuum
3. Create a continuum with closed skills at one end and open skills at the other. In pairs, discuss where each of the following activities would sit. Give reasons for your answers.
• 100-metre sprint
• Archery
• Marking in Australian Rules Football
• Motor car racing
• Receiving a pass in netball
• Serving in tennis
• Vault in gymnastics
• Tenpin bowling

4.4 Check and challenge
Elaborate
1. For each of the five categories of skills, list three skills or activities that exhibit the characteristics of that type of skill.

Evaluate
2. Which of the stages of skill learning do you think requires the most input from a coach? Why?
3. Which of the five categories of skills do you believe would be the most difficult to teach or learn? Which would be the easiest? Justify your answers.
4.5 Factors affecting skill acquisition

Increasing your skill proficiency is important to be able to cope with changing movement contexts and to achieve a higher level of performance. It is influenced by the amount and type of practice you undertake. Receiving the appropriate feedback is also vital in order to improve skill execution.

4.5.1 Practice, feedback and transference

Skills are learned by practising in a range of ways. Practice is important, but so too is feedback about the performance. This is often provided by a teacher or coach, who should understand that a number of factors can influence skill learning. These factors include practice, feedback and transference.

Skills can be practised as a whole or broken down into parts. In a sample week, practice can be spread over a number of sessions or be completed in one intense block. Which of these methods is best for learning a new skill? In this subtopic, each of these methods is investigated and you will be able to make a decision about which is best.

4.5.2 Practice

Practice is essential for the acquisition and development of movement and sport-specific skills. The teacher or coach should be aware of the different types of practice and should select the method that optimises the individual’s ability to learn.

The role of practice should be:
- to develop skills correctly leading to their execution in an environment that resembles, as closely as possible, the game or final performance situation
- to understand and correct errors using feedback
- to learn how to use equipment safely
- to develop positive relationships
- to experience success
- to develop important values, such as fair play
- to have fun and enjoy being challenged.

The main types of practice

Massed and distributed practice
Whole or part practice
Mental and physical practice
Massed and distributed practice

Massed practice involves practice for an extended period of time. This type of practice is most suitable for highly skilled and motivated performers. An example would be practising 50 tennis serves in succession.

Distributed practice involves short sessions interspersed with periods of rest, during which either feedback is provided, or another skill is practised. Distributed practice is more suitable when the athlete is learning a new skill, when the skill is complex and/or physically demanding or when the learner’s motivation is not high.

Whole or part practice

Whole practice involves practising a skill in its entirety, whereas part practice involves breaking down the skill to practise it in parts. Some skills are best practised in their entirety; for example, a golf swing. Other more complex serial skills, such as a basketball lay-up, might best be broken down into component parts, with each part practised in isolation, before the parts are combined and practised as a whole. In this example the dribbling and shooting components would be practised in isolation before they are combined for the lay-up.

Physical and mental practice

Most of us are familiar with physical practice, which involves actually performing a skill. In contrast, mental practice or visualisation is a form of practice commonly used by elite athletes. This type of practice involves visualising a sporting scenario and imagining successful performance in your mind. It involves imagining through all the senses: seeing the performance executed, hearing noises such as the crowd, feeling objects that are being manipulated and the way the body is moving through space. The key to effective mental practice is to visualise the correct and successful execution of skills. When this is supported by physical practice, skills are learnt more effectively and rapidly. Good practice relies on using both mental and physical techniques.
4.5.3 Feedback

Feedback provides us with information about the quality of our performance. This is usually in the form of knowledge of performance or knowledge of results.

Knowledge of performance is information about the actual quality of performance itself; for example, was the skill performed with the correct technique? This feedback may be provided by an external source, such as the coach, or it may come from the individual performing the skill who has a ‘feel’ for the quality of the performance.

Knowledge of results is feedback about the outcome of the movement or performance; for example, whether a serve in tennis was in or out.

There are other types or forms of feedback. Internal or kinaesthetic feedback is about the ‘feel’ of the movement. For example, a golfer can often feel whether the shot was a good one by the way the movement felt and the way his or her body flowed during its execution. On the other hand, external or augmented feedback can be provided by visual, verbal or aural (hearing) signals. For example, a golfer can tell that he or she hit the ball well by the sound made on contact, by seeing the ball flying down the fairway or by being told that the shot was a good one.

Feedback is very important if players are to improve. For feedback to be effective, it is best given as soon as possible during or after the performance and it should be constructive rather than negative. People are much more receptive to feedback that is positive in nature. It is likely to motivate more, increasing the likelihood of the performer practising more, increasing their success, which then serves as a further motivational tool. The precision of the feedback given is also very important. General feedback such as ‘well done’ is good for encouraging beginners. Feedback such as ‘you need to follow through more at the end of your throw’ followed by ‘try putting your throwing hand in your back pocket after you have released the ball’ is more specific and valuable for the learner. It is vital that a teacher or coach moves around and provides feedback to as many individuals as possible within a group. It is important to respond to feedback effectively so that individuals and teams can optimise their performance.

DID YOU KNOW?

People are able to process only two or three pieces of information at once. Feedback regarding performance should be limited and should be given as soon as possible upon completion of the skill.

4.5.4 Transference

Skill transference occurs when the learning or development of one skill can be used in the acquisition and development of another skill. This is possible because we are able to withdraw past experiences from our skills bank and transfer them to similar movements and skills. For example, there are certain similarities and basic principles that apply to all methods of kicking, regardless of whether it is in rugby, Australian Rules Football or soccer. Transference can also relate to the way individuals think about rules, space, time, tactics and strategies. Familiarity with the use of space and time in soccer when leading for the ball, for example, can be beneficial to hockey and lacrosse. Use the Transferring skills weblink in the Resources tab to see how the skills of AFL football can be applied to a wide range of sports. Discuss examples of the high level of
Skill evident in the clip. Consider the types of training and learning environments these individuals may have experienced.

Transference also enables a player to adopt movement strategies and elements appropriate for a game or performance. This includes athletes being aware of their own body in relation to space, such as in a diving or gymnastics routine. This spatial awareness is vital in team games, as performers need to be aware of other players and their movements. An understanding of the elements of space and time are vital for an athlete to thrive in sport. The use of time and space can be manipulated by skilled performers to improve the chances of a successful outcome. Examples include:

- **use of space** — space can be used by a team to enable a performer more time while in possession of a ball, increasing the likelihood of an accurate pass. This can be achieved in a sport such as soccer where a ball is passed to a player on the other side of the field. Conversely, defenders attempt to close down space, to apply pressure on the ball carrier and reduce their time in possession.
- **use of time** — time can be used to advantage. A basketball team playing against another who has poor speed may increase the speed of play and therefore effort to reduce the time available for the opponents to defend the ball, increasing the chance of success.

### 4.5 Activities

**Do it**

1. Complete the laboratory activities in the **Feedback** worksheet in the Resources tab and comment on the effect of feedback on performance.

**Transfer**

2. Organise the class to play a game of netball and a game of basketball. Complete a table, such as the one below, listing skills that are transferable between the two sports and those that are specific to each sport.

<table>
<thead>
<tr>
<th>Transferable skills</th>
<th>Netball-specific skills</th>
<th>Basketball-specific skills</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Resources**

- Digital doc: Worksheet 4.5 Feedback (doc-29286)
- Weblink: Transferring skills
4.5 Check and challenge

Explain
1. List three key factors that affect skill learning.
2. Use an example to illustrate the difference between internal and external feedback.

Evaluate
3. Evaluate how open and closed environments affect the learning of skills.
4. What type of feedback is most useful for your learning?

Elaborate
5. Explain who would benefit from distributed practice.
6. How is skill transference important for achieving and promoting an active lifestyle?
7. Describe an open skill from a sport of your choice and explain how you would ‘close it down’ when teaching it to a beginner, and then gradually ‘open’ the skill when success has been achieved at the previous stage.

4.6 Biomechanics

Biomechanics is an area of sports science that applies the laws of physics and mechanics to promote performance in sport. Principles of biomechanics are concepts that can be applied to increase skill proficiency and by learning these principles, you can adapt movement skills and sequences. As principles have common laws, they are often learned in one skill or sport then transferred to another similar sport. Additionally, biomechanical principles can be applied to assist injury prevention and modify equipment or clothing to further enhance your performance.

4.6.1 Using biomechanics to produce better results

Knowledge and application of biomechanics can assist athletes and coaches to produce better results. In this subtopic several key biomechanical concepts will be presented to help explain how each can be applied to improve performance. When combined with good technique, the skill is likely to be smooth flowing, require little energy expenditure and have a high level of accuracy. The concepts to be presented are:

- application of force
- projectile motion
- balance and stability.

The Fosbury Flop is a high jump technique pioneered by Dick Fosbury at the 1968 Olympic Games. Fosbury was successful in clearing 2.24 metres because this technique allowed him to clear the bar in an arched position while his body’s centre of mass passed under the bar. This is an excellent example of how biomechanical principles can be applied to improve athletic performance. Fosbury’s technique is still used today by all elite high jumpers.
Use the **Fosbury Flop** weblink in the Resources tab to see footage of Dick Fosbury’s performance at the 1968 Olympic Games.

4.6.2 Application of biomechanics

Biomechanics studies the forces and their effects on and within the human body and objects such as a ball or bat. Understanding biomechanics can produce the following benefits for coaches, teachers and athletes:

- optimisation of skill performance and proficiency by developing the most efficient and effective technique
- enhance the design and development of improved equipment and materials to maximise sports performance, as well as the development and modification of sports equipment to enhance the participation experience; for example, junior-sized equipment allows participation at a younger age
- transference of skills from the practice field to the playing field; for example, batting tees, ball-throwing machines, swimming flumes, and video and computer software allows athletes to enhance technique in practice and apply this in competition
- prevention and reduction of injuries through an understanding of the causes of injury and the development and application of proper technique and equipment and therefore the speed of the athlete.

4.6.3 Force production and application

The performance of all movement and motor skills — including running, jumping, throwing, kicking and striking — requires internal muscular force being produced and applied. How effectively the force can be developed and applied often goes a long way towards determining the proficiency with which the skill is performed. The following biomechanical principles are important factors to consider in force production and application.

**Summation of forces**

Summation of forces is necessary when a maximal effort is required, such as kicking a football for distance, throwing a javelin, fast bowling a cricket ball, performing the high jump or performing a vault in gymnastics. This summation means the adding of different body parts to accumulate a greater overall force via the contribution of all these parts. To achieve the best results, the individual must combine movements of these different body parts into a coordinated sequence of movements. Summation of force can occur in two ways: the sequential summation of force or simultaneous summation of force.

Sequential summation of force is when a sequence of body movements takes place, starting with the larger, more powerful body parts to produce the initial force, and then transferring this force to the next moving part and eventually finishing with the smaller, lighter body parts. To achieve the greatest possible force, each segment must contribute by developing its greatest force before the next body part comes into action. As well as developing the maximum force of each preceding body part, each subsequent body part needs a stable base to summate the force effectively.
Fast bowling in cricket is a good example of sequential summation of force. In the delivery action, there is a sequence of body movements beginning with the larger, heavier body parts (legs, trunk) and finishing with the smaller, lighter body parts (wrist, hand).

1. The first part of the delivery action is the step forward onto the front foot.
2. This then provides a stable platform for the rotation of the hips and trunk.
3. Momentum is then transferred to the shoulder and the arm swing, followed by wrist flexion and the release of the ball from the hand and fingers.

The figure below illustrates the concept of sequential summation of force in bowling.

Players who cannot throw a ball as far as expected may not be carrying out summation of forces correctly. You may need to ask yourself when analysing the movement or skill:

- Are as many body parts as possible being used to contribute to the desired outcome?
- Are the body parts that are larger and stronger operating before the smaller, faster muscles?
- Are the body parts being used accelerating in the correct order, so that each body part contributes to an optimal level before the next body part comes into operation?
- Is each body part stabilising around a solid base to enable each following action to accelerate optimally?
- Are the body parts that are lighter but that move more quickly used at the point of release? You may like to apply this to other skills such as a badminton clear or a javelin throw.

Simultaneous summation of force takes place when an individual performs a skill such as the high jump or a gymnastics vault. The performer carries out an explosive action with maximum force over a very short period of time. The aim of this type of force production is to develop vigorous and powerful movements of the arms and legs to produce a powerful take-off.

**Impulse**

Another means of increasing the amount of force production or momentum imparted during a movement is by applying the force for a longer period of time. This is the principle of **impulse**. Impulse is important in many sports, including the start of the 100-metre sprint in athletics, leaving the blocks in swimming, pitching in softball and baseball, the discus throw and performing the push pass in hockey. For example, in discus, it is beneficial to perform a circular spin before releasing the discus, rather than throwing from a standing position; this allows the athlete more time to generate muscular force.

In the 100-metre sprint, two techniques are used at the start of the race to generate greater impulse:

1. pushing from the blocks to maintain a strong forward force for as long as possible
2. taking short, sharp steps over the first 10–20 metres, which allows the feet to push repeatedly against the track and magnify the force applied and therefore the speed of the athlete.
Absorption of force
Just as a person can generate force by applying it over a period of time, the same principle can be used to absorb force. This is important in instances such as catching a ball. Absorbing the force means that the object that is in motion is being slowed or stopped. The longer the force is absorbed the less impact the object has and the easier it is to slow down. This absorption of force can be achieved via a number of ways. Examples include altering the technique of a skill or by using equipment that can absorb the impact for a period of time. Some examples are listed in table 4.1.

<table>
<thead>
<tr>
<th>TABLE 4.1 Examples of absorption of force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption of force by altering technique</td>
</tr>
<tr>
<td>A cricketer attempting to catch a hard cricket ball will let the ball hit their hands and move their hands in the direction the ball is going, enabling the force to be absorbed over time.</td>
</tr>
<tr>
<td>A netballer who jumps up to receive a pass will land and attempt to absorb the force over a long period of time. This is achieved by bending their knees when landing and continuing to do so until the force is absorbed.</td>
</tr>
</tbody>
</table>

Accuracy
In some sports, maximum force is not required; rather, accuracy is more important. Accuracy in throwing and striking can be improved by 'flattening the arc'. This is achieved by moving the axis of rotation (the shoulder joint) forward in the direction of the throw just prior to the time of release of the ball. The arm should straighten as the shoulder moves forward because of the transfer of weight onto the front foot and the rotation of the trunk.

When a player serves in tennis (see the figure at right), he or she creates a flattened arc of the racquet head by the shift of body weight forward and the rotation of the body prior to the moment of contact. When a player hits a softball, the arc is flattened due to the rotation of the trunk, which moves the shoulders forward, and the transference of weight onto the front leg just prior to contact.

Resources

Interactivity: Cricket: fast bowling (int-5484)
4.6.4 Projectile motion — velocity of release and angle of release

Throwing, striking and kicking skills all involve objects such as balls and implements (for example, discus or javelin) being projected into the air. In biomechanics, this is known as projectile motion, where the object moving through the air is referred to as a projectile. A projectile’s flight path (trajectory) is influenced by a number of factors, of which velocity of release and angle of release are the most important.

Velocity of release

Velocity of release is the most important factor for achieving maximum distance of a projectile. The greater the velocity of release, the greater the distance achieved. Velocity of release is largely determined by the principles of force production (summation of force and impulse) discussed previously.

Angle of release

When attempting to achieve maximum distance in throwing and kicking skills, the optimal angle of release of a projectile is 45 degrees for any given velocity of release. This angle of release provides equal components of vertical and horizontal force. However, this applies only when the height of release and height of landing are the same, and when spin and air resistance are not present. Given that this is rarely the case, the optimal angle of release for achieving maximum distance in most sporting activities is usually less than 45 degrees, with an angle of between 35 and 45 degrees being most common. The figure below shows the optimal angles of release for various sporting skills. When height is required, the angle of release increases, such as during a pole vault or high jump.

![Optimal angles of release and associated trajectories for various sporting skills](image)

4.6 Activities

**Summation of forces**

1. Use the Summation of forces worksheet in the Resources tab and complete the activity.

**Projectile motion**

2. Use the Projectile motion worksheet in the Resources tab and complete the activity.
Analysing the use of force using ICT

3. In pairs, use the Video analysis software weblink in the Resources tab or similar software on your laptop, tablet or smartphone to record a partner bowling a cricket ball. After recording this action, compare it to the action found in the bowling illustration in section 4.6.3. Based on these comparisons, make suggestions about how the performer can generate more force. Swap over on completion.

4. Describe the benefits of using digital tools in helping to analyse a particular movement, such as a bowl in cricket. What feedback can be provided that a coach cannot provide? Describe the link between feedback and improved performance, using this activity as a guide.

Resources

- Digital doc: Worksheet 4.6 Summation of forces (doc-29287)
- Digital doc: Worksheet 4.7 Projectile motion (doc-29288)
- Weblink: Video analysis software

4.6 Check and challenge

Explain

1. Explain the concept of impulse and its relationship to the amount of force or momentum that can be generated during the performance of a skill, such as throwing or kicking for distance.

Elaborate

2. Outline the difference between simultaneous and sequential summation of force.
3. Identify the three sporting skills that require sequential summation of forces and three that require simultaneous summation of forces?

Evaluate

4. Identify the benefits that a knowledge of biomechanics can provide for coaches, teachers and athletes?
5. Select one of the following activities and then identify the biomechanical principles which can be applied to it. In each case, describe how the principle operates for the activity you have chosen.
   - (a) Javelin throw
   - (b) Tennis serve
   - (c) 100-metre sprint

4.7 Review

4.7.1 Summary

- Fundamental motor skills are common movement activities such as running, jumping, catching, throwing, kicking and striking. They are the building blocks of the more specialised, complex skills used in games, sports and physical activities.
- Measures used to assess movement proficiency include observation; checklists; rubrics and rating scales; measurements; norm- and criterion-referenced standards and percentile ranks; and statistical information.
- Teachers and coaches often possess movement and sport-specific knowledge and experience, as well as an understanding of the principles of skill acquisition and biomechanics.
• Skill acquisition is the movement science concerned with the processes and ways in which individuals acquire and learn motor skills.
• There are three stages of learning, each of which has its own performance characteristics.
• Feedback and practice are two other important factors affecting skill learning and acquisition.
• Practice prescription will vary according to the stage and motivation of the learner and the complexity of the task.
• Biomechanics is the science that applies the laws of mechanics and physics to human movement.
• Summation of forces can involve either sequential summation of forces or simultaneous summation of forces.
• Impulse refers to the amount of force applied to an object and the period of time over which this force is applied. It is important in many sports, including the sprint start technique in athletics, pitching in baseball and performing the push pass in hockey.
• Accuracy in throwing and striking skills is often obtained through the application of the concept of ‘flattening the arc’.

**ESSENTIAL QUESTION**

Why is it important to identify and measure the proficiency of movement in athletic performance?

Evaluate your initial response to the essential question now that you have studied the topic.

4.7.2 Key terms

- **activity analysis** recording and analysing movement and skill data from a game, sport or activity; the data is analysed to appraise a player’s performance
- **angle of release** angle at which a projectile is released
- **associative stage** second stage of skill learning. During the associative or practice stage, the individual is beginning to get the feel of the movement and fewer errors are made.
- **augmented feedback** information provided by visual, verbal or aural (hearing) signals
- **autonomous stage** third and final stage of skill learning. In the autonomous or automatic stage, the individual is able to complete the skill virtually without conscious control.
- **closed skills** skills performed in a stable and predictable environment. They allow the performer to plan his or her movements in advance.
- **cognitive stage** first stage of skill learning. Individuals who are at the cognitive or beginner stage need to know how to execute the basic movement patterns of the skill in correct sequence.
- **continuous skills** skills that have no distinct beginning or end; such skills or movements are often repetitive or rhythmic in nature
- **discrete skills** skills or movements of brief duration that have a distinct beginning and end
- **distributed practice** short sessions interspersed with periods of rest, during which either feedback is provided, or another skill is practised
- **feedback** information provided to a performer about the quality and/or outcome of the performance
- **fine motor skills** skills that involve a small number of muscles and accurate movements
- **gross motor skills** skills that involve many muscles and a large degree of force
- **impulse** the force applied to an object and the length of time the force is applied
- **key elements** distinct actions that join to make up a movement phase of a skill
- **kinaesthetic feedback** feedback about the ‘feel’ of a movement skill
- **knowledge of performance** feedback about the quality of performance itself
- **knowledge of results** feedback about the outcome of the performance
- **massed practice** practice of a longer duration
- **mental practice** involves imagining or visualising a skill in the mind
**objective judgements** utilise methods, techniques or tools for appraising the proficiency of the movement performance

**open skills** skills performed in an environment that is variable and unpredictable; usually externally paced and performed in a constantly changing environment

**part practice** breaking down and practising a skill in its ‘parts’ or subroutines

**performance measures** methods, techniques or tools for judging or assessing the level of performance

**physical practice** practice in which the skill is actually performed physically

**proficiency of movement (or skill proficiency)** the achievement or attainment of a movement goal with maximum certainty, minimum energy expenditure and minimum movement time (where speed is essential)

**projectile** the object propelled into the air as a result of force application, such as a soccer ball or even a body itself

**projectile motion** the motion of objects such as balls or implements that are thrown, struck or kicked into the air

**qualitative analysis** process of observing, analysing and appraising human movement performance

**serial skills** series of discrete skills strung together to form a more complicated action

**skill** learned ability to bring about predetermined results with maximum certainty, often with minimum outlay of time or energy or both

**subjective judgements** judgements based on feelings or impressions and which do not involve the use of techniques or tools for appraising the proficiency of the movement performance

**velocity of release** single most important factor for achieving maximum distance of a projectile; the greater the velocity of release, the greater the distance achieved

**whole practice** form of practice in which a skill is practised in its entirety

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### 4.7 Check and challenge

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Key terms quiz**

**Multiple choice quiz**

**Check your understanding**

1. Link a fundamental movement skill to a manipulative skill by describing an example of how this works in a sport of your choice.
2. Explain how you would ensure consistency in assessing a gymnastics or dance routine. List the criteria you would expect judges to follow.
3. For a specific sporting skill, outline a plan of action to take a beginner from the cognitive stage through to the associative stage of skill learning.
4. For a specific sporting skill, explain how you would close this skill down so that a beginner could learn it, and then how you would gradually open it up as the learner became more proficient.
5. Select a sport and describe a typical training session that improves performance in a game situation.

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**Resources**

- Digital doc: Worksheet 4.8 In my words (doc-29289)
- Digital doc: Worksheet 4.9 Key terms quiz (doc-29290)
- Digital doc: Worksheet 4.10 Multiple choice quiz (doc-29291)
- Digital doc: Key terms glossary (doc-29292)