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Self-regulation theory: Applications to medical education: AMEE Guide No. 58

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Abstract

Self-regulation theory, as applied to medical education, describes the cyclical control of academic and clinical performance through several key processes that include goal-directed behaviour, use of specific strategies to attain goals, and the adaptation and modification to behaviours or strategies to optimise learning and performance. Extensive research across a variety of non-medical disciplines has highlighted differences in key self-regulation processes between high- and low-achieving learners and performers. Structured identification of key self-regulation processes can be used to develop specific remediation approaches that can improve performance in academic and complex psycho-motor skills. General teaching approaches that are guided by a self-regulation perspective can also enhance academic performance. Self-regulation theory offers an exciting potential for improving academic and clinical performance in medical education.

Introduction

In this theory-to-practice Guide, we will initially provide an integrative overview of self-regulation theory, as described by various scholars in educational psychology. Although we adopt a social-cognitive perspective, our aim is not to focus primarily on any one theoretical model but to provide a summary of the main theoretical principles shared among diverse perspectives. We will then discuss some of the extensive research that has been performed across a variety of non-medical disciplines. This research includes studies that highlight differences in key self-regulation processes between high- and low-achieving learners and performers, the use of structured identification of key self-regulation processes to develop specific remediation approaches and general teaching approaches that are guided by a self-regulation perspective. Finally, we will provide some practical tips to show how medical educators can use self-regulation theory and principles to inform teaching and learning. Many current approaches to teaching and learning in medical education already apply some aspects of self-regulation theory, such as encouraging students to set goals for their learning, but our opinion is that a more thorough application of the theory can benefit educators as they seek to enhance student academic and clinical performance.

Practice points

- Self-regulation theory, as applied to medical education, describes the cyclical control of academic and clinical performance through several key processes that include goal-directed behaviour, use of specific strategies to attain goals, and the adaptation and modification to behaviours or strategies to optimise learning and performance.
- There are differences in key self-regulation processes between high and low achieving learners and performers.
- Structured identification of key self-regulation processes can be used to develop specific remediation approaches that can improve both performance in academic and complex psycho-motor skills.
- General teaching approaches that develop key self-regulation processes can enhance academic performance.
- Self-regulation theory offers an exciting potential for improving academic and clinical performance in medical education.

What is self-regulation?

Self-regulation has been defined as, 'self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals' (Zimmerman 2000, p. 14). It is largely considered to be a process by which an individual seeks to accomplish goals through the self-directed use and modification of highly specific strategies. This process has been linked to optimal functioning in children, adolescents and adults across a diverse range of disciplines and content areas, from academic, athletic and music performance to the maintenance of mental and physical health (Cleary & Zimmerman 2001; Bandura 2005; Graham & Harris 2005; McPherson 2005). In addition, given the great range in interests and theoretical perspectives across these diverse domains, a variety of 'regulation-related' terms have been used in the literature, such as executive functioning, self-management, self-directedness, self-monitoring and self-control.

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For the purposes of this Guide, however, we will confine our discussion of self-regulation to describe the cyclical control of academic and clinical performance through several key processes that include goal-directed behaviour, use of specific strategies to attain goals, and adaptation and modification to one's behaviours or strategies to optimise learning and performance.

Self-regulation theory in practice

There are several empirically supported self-regulation models which delineate a set of distinct processes through which individuals exert control of their behaviour (actions), cognition (thoughts) and/or environment (surroundings) (Puustinen & Pulkkinen 2001). A few examples of well-researched theories of self-regulation in academic contexts include social-cognitive cyclical models (Zimmerman 2000), information processing approaches (Winne & Hadwin 1998) and Boekaerts' (1992) model of adaptive learning.

Social-cognitive models of self-regulation, which are historically based on the work and theories of Bandura beginning in the 1960s and 1970s, suggest that individuals are active participants in their lives who seek control over important events through the regulation of their thoughts, actions and environmental factors to achieve personal goals (Bandura 1986). From this perspective, reciprocal interactions among behaviours, the environment and personal factors, such as beliefs and affect, are assumed. At any given time, one factor may predominate. For example, reading a book may be inhibited by an excessively noisy environment or due to a person's lack of interest in the content of the book. Bandura would argue that humans are not merely passive participants in learning, but that they proactively seek to exert control over their behaviour and learning environment or context. In the illustrative example of reading a book, frustrated students can actively structure their learning context to attain their goal of reading the text, such as arranging a more quiet study environment or engaging in motivational self-talk regarding the importance or value of reading the book. This active process of making adjustments in the pursuit of personal goals is at the heart of self-regulation and is largely mediated by an individual's self-beliefs and judgements, such as self-efficacy. Perceptions of personal competency are powerful determinants of one's ability to direct and sustain efforts in the face of fatigue, boredom or stress. A person with low self-efficacy beliefs will doubt his or her ability to succeed and thus will often not display adequate effort or persistence when challenged by a task.

In this Guide, we will focus on three important characteristics of self-regulated learners that are shared across the various theories: (1) goal-directed behaviour, (2) use of specific strategies to attain goals, and (3) the adaptation and modification to one's behaviours or strategies to optimise learning. Furthermore, given that most theorists conceive of self-regulation as a super ordinate process characterised by various sub-processes, such as goal-setting, planning, strategy use, self-control, self-monitoring and self-reflection (Puustinen & Pulkkinen 2001), we first describe the nature and characteristics of this cyclical approach to learning.

Cyclical regulation. Depicting self-regulation as a 'cyclical loop' means that individuals will engage in an iterative process during which they proactively use task-specific and metacognitive strategies, and continuously gather information about the effectiveness of these strategies in achieving their goals. Although theories will differ in terms of the precise nature or number of phases within this loop, most typically conceptualise self-regulation as a process with *before (or forethought)*, *during (or performance)*, and *after (or self-reflection)* phases (see Zimmerman 2000 for a social-cognitive perspective on self-regulation). See Figure 1.

(a) Before (or forethought) phase

Sophisticated self-regulated learners will proactively 'prepare' by seeking to understand the nature of an assignment or activity and then setting goals and specific plans to perform well on that learning task. For example, a student may skim read an article that he or she has to read and then set short-term and specific goals to understand each section before moving onto the next section. Zimmerman (2000) argues that this preparatory phase underscores the proactive essence of self-regulated learners and that such preparatory thoughts and actions facilitate adaptive self-evaluation and reflection after learning has occurred. It is also important to note that self-motivation beliefs, such as self-efficacy, goal orientation, and task interest or value, provide the impetus or motivation for a learner to put forth the necessary effort to engage in the self-regulation process.

(b) During (or performance) phase

Self-regulated learners will also attempt to control their behaviours and thoughts *during* learning by employing specific tactics, such as attention focusing, relaxation, positive self-talk and mental rehearsal of the steps of a procedure (Wolters 2003). As an example, a student may structure his or her study environment so that it is free of distractions, use positive self-instruction statements to motivate himself or herself when fatigued, and enlist a variety of study tactics, such as to produce concept maps, make summaries and practice quizzing, to enhance his or her learning of course material.

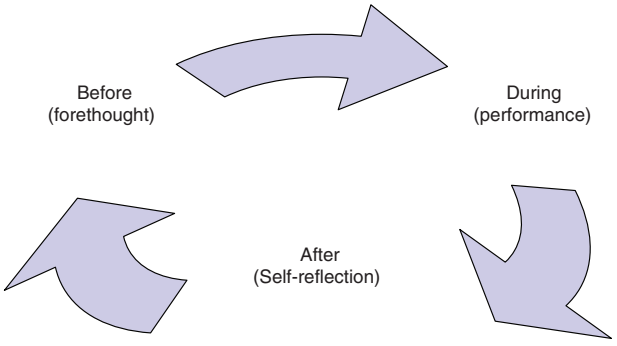

Figure 1. Phases of self-regulatory processes.

Regulated individuals are highly strategic in nature and thus will actively seek to manage emotions, cognition and behaviour in order to attain their forethought goals. It is important to note that many theorists emphasise the role of metacognitive control and self-monitoring as students learn or perform (Winne & Hadwin 1998; Zimmerman 2000). That is, the extent to which students can skilfully observe, or notice, when learning is successful or not and then to identify the contributing conditions or factors influencing that learning is a key regulation process.

(c) After (or self-reflection) phase

Students' knowledge of the specific tactics they use to learn as well as information related to the success of these strategies sets the foundation for the *after* phase of self-regulation (Zimmerman 2000). It is during this final self-reflection phase of self-regulation in that individuals self-evaluate whether they have attained their goals and seek to identify the primary factors causing them to succeed or struggle. Self-regulation theorists would argue that this latter type of cognitive self-judgement, called attributions, is of particular importance when students struggle with academic performance. Causal attributions are highly predictive of students' subsequent behaviours and motivation to sustain learning (Weiner 1986). Theorists who support a cyclical viewpoint of self-regulation would also suggest that after students engage in reflection, they will make decisions about modifying or adapting their goals or strategies for future learning, thereby initiating the next iteration of the regulatory feedback loop. For example, a highly adaptive self-regulated student who fails to attain the assessment grade that he or she expected to achieve will typically make attributions to highly specific processes or strategies that were initially used to learn. Strategic attributions are ideal because strategy use is inherently changeable and thus can be modified or adjusted prior to engaging in a new learning activity. It is when students blame their struggles to fixed personal factors, such as poor ability, or to external and uncontrollable factors, such as luck or the skill of the teacher, that poor motivation and disengagement become most pronounced in these individuals.

Many academic self-regulation intervention programmes teach students to engage in this cyclical process of regulation across various academic tasks, such as writing, solving math problems or learning science (Graham & Harris 2005; Cleary et al. 2004) Furthermore, experimental research illustrates the motivation and performance advantages of multi-phase training, that is training in the before, during and after phases of self-regulation (Cleary et al. 2006).

Goal-directed behaviour. The initial phase of cyclical regulation involves engagement in forethought, collectively referred to as a set of processes occurring before learning or performance of a task (Zimmerman 2000). One of the key subprocesses within this phase is goal-setting, which has been defined as the standards or specific outcomes of learning or performance that are personally established by an individual (Locke & Latham 1990). Goals are important in self-regulation models because they serve a motivation function and can direct students' attention on specific aspects of the learning process or outcomes. Zimmerman (2008) provides an informative overview of the nature of goal-setting as well as the essential properties and characteristics of effective goals, such as short-term versus long-term, proximity and difficulty level. Of particular importance to this Guide, however, is the distinction made between process and outcome goals.

Outcome goals tend to emphasise the final products of learning, such as a test grades, where process goals involve the steps, procedures or strategies that one employs to learn (Zimmerman & Kitsantas 1996). Although outcome goals can exert positive motivational and regulatory effects, process goals are particularly beneficial in situations when students are first learning how to perform a task or skill or when they struggle to master the task. Several experimental studies have shown that students who are taught to establish process goals for a particular task will often outperform and be more motivated than those who have only set outcome goals (Schunk & Swartz 1993; Zimmerman & Kitsantas 1996); although subsequent research highlights that student achievement can be maximised when they are taught to shift from process to outcome goals after mastery of a strategy or skill has been attained (Zimmerman & Kitsantas 1997).

Researchers have found that students who have attained a high level of proficiency or expertise on a task report setting process goals more frequently than outcome goals. For example, Kitsantas and Zimmerman (2002) showed that expert volleyball players set significantly more process-oriented goals (i.e. goals that focused on volleyball serving strategy) than non-experts and novices. Furthermore, in a qualitative study employed in a medical education context, Cleary and Sandars (2011) showed that medical students who demonstrated proficiency on a venepuncture task consistently displayed process or technique goals, whereas those who struggled with this procedure (need to have three attempts to successfully draw blood) tended to emphasise outcome goals. In short, goals are critical in any theoretical model of self-regulation because they serve a motivational role, direct students' attention on the content of the goal during learning, and act as the standards against which individuals self-evaluate their success in school.

Strategic awareness and behaviours. Students who proactively establish process goals and who develop strategic plans are more likely to use such strategies during task performance. However, it is important to note that there are different classes or types of strategies, with each having distinct purposes and goals. Self-regulation theorists draw a distinction between strategies or tactics aimed at managing motivation versus those designed to maximise acquisition of information or learning (Zimmerman 2000; Wolters 2003). In short, self-control strategies, such as self-reinforcement, self-instruction and environmental structuring, are designed to direct students' attention to the task of interest and to sustain effort and persistence. In contrast, learning strategies, such as using concepts maps, identifying key terms to study and comparing class notes to textbook information, facilitate learning and performance because they break down a task to its component parts and

clearly direct students' attention on how to process and recall information in an efficient manner (Zimmerman 2000). It is important to note that training students to become strategic thinkers and users is a central component of most academic self-regulation intervention programmes, regardless of academic content or age of the students. That is, students are taught to think strategically when setting goals or making plans, during attempts to learn, and reflecting on the sources of one's successes or struggles.

Adaptation and flexibility. The extent to which individuals set goals or use strategies to perform at an optimal level loses much of its value if individuals are not skilful in making adjustments or adaptive changes when confronted with challenges and obstacles. The extent to which students adapt their goals or strategic plans is of greatest importance when students struggle in school. In these 'reflective' situations, students are invariably called upon to identify both the primary errors linked to the poor performance as well as the strategies or tactics needed to improve performance in the future. Similar to all phases of the cyclical loop, the self-reflection or 'after' phase involves several sub-processes, such self-evaluation (comparing performance to goals or standards), attributions (perceived reasons for performance) and adaptive inferences (conclusions regarding modifications or adjustments required to improve learning) (Zimmerman 2000). Although all these sub-processes are important, we will focus on causal attributions because this type of cognitive judgement often serves as the key fulcrum point around which effective modification and adaptation occur.

Attribution theory postulates that human beings are motivated by the need to understand themselves as well as the environments in which they learn and perform (Weiner 1986). As part of this process to understand, individuals attempt to identify the causal determinants of their behaviours and the outcomes emanating from their actions. Of particular relevance to education contexts is that the types of attributions students make will impact their cognitive, affective and behavioural reactions following failure and thus are quite predictive of future learning efforts. According to Weiner, attributions can be classified into of one of three dimensions: locus (cause is either internal or external), stability (how stable the cause is over time), and controllability (extent to which the can be controlled). Researchers have shown that when students struggle to succeed or when they encounter challenges during learning, those who make internal, unstable and controllable attributions, such as effort and strategy use, tend to be high achieving and adaptive in their persistence and use of strategies (Cleary & Zimmerman 2001; Cleary et al. 2006). From a social-cognitive perspective, both these types of attributions are adaptive because they enhance students' perceptions of efficacy to improve (Bandura 1997). According to Bandura, sustaining a sense of personal efficacy in the face of failure or poor progress is one the most important factors in sustaining students' effort and persistence. In addition to this motivational advantage, however, is that making strategic attributions following failure will direct students' attention on the key strategies, processes or techniques that are ultimately linked to successful task performance (Cleary et al. 2008). Consistent with self-regulation theory, strategic attributions will impact the types of adaptive inferences or conclusions that students make about how they need to improve – an essential aspect of a self-regulated learner.

Research has found that training students to make strategic attributions can improve their performance. For example, Cleary et al. (2006) conducted an experimental study to examine the effects of self-regulation training on the shooting performance and regulatory processes of novice basketball players. Participants were randomly assigned to one of three regulatory conditions or a control group. Participants in this study who were taught to make strategic attributions following missed free-throws, such as '*My elbow was not straight*' or '*I did not have a proper grip of the ball*', were more likely to make strategic adaptive inferences. That is, students who attributed their missed free-throws to poor strategy use were more likely to conclude that they needed to modify or adjust their shooting technique in order to improve. It should be noted that students who made strategic attributions following missed free-throws, showed better skill at quickly adjusting their shooting performance *during* the practice session than those who did not receive such training.

In conclusion, academic self-regulation theories provide a template from which one can understand how malleable psychological processes interact to influence *how* individuals approach a learning or performance task. Most of these theories describe self-regulation in terms of a cyclical process that includes distinct sub-processes occurring before, during and after individual's engage with a task. In addition, research has shown that students who consistently use self-regulation skills typically perform at a higher level than those with less well developed skills. Of greatest importance is that self-regulation theory is a promising framework for medical education because self-regulation skills can be developed by structured training.

The application of self-regulation theory to medical education

Many current approaches to teaching and learning in medical education apply some aspects of self-regulation theory, such as goal setting in problem-based learning (Lycke et al. 2006). However, in our opinion, the use of a comprehensive theoretical model of self-regulation has the potential to further inform the practice of medical education if specific attention is paid to implementing key self-regulation processes in teaching and learning, such as encouraging and facilitating student goal-directed behaviour, use of specific strategies to attain goals, and the adaptation and modification of strategies when goals are not met. In this section, we will provide some practical tips on how self-regulation theory can be used in medical education across two main areas: improving academic achievement and improving clinical performance. We will also describe some general instructional approaches, including the importance of the role of a tutor and learn-to-learn courses, and discuss the importance of feedback that has a focus on self-regulation processes.

Improving academic achievement

Previous research has shown that self-regulation is a distinguishing characteristic between high and low academically achieving college students. Kitsantas (2002) found that high-achieving students with a high test score set more strategic process goals, self-monitored their progress and used self-evaluation to make judgements about their performance on the test. High achievers also reported having greater self-efficacy regarding their ability to perform well on the test and perceived the test as being more important compared to those who scored lower on the test. Important for all educators is that specific training to develop self-regulation processes can improve academic achievement. For example, Zimmerman and Kitsantas (1999) found that students who shifted their forethought goals from processes to outcome outperformed those who used process goals, who in turn, surpassed those who only used outcome goals. Individuals in the shifting goal group were superior in their writing revision skill, and had greater self-efficacy and self-reaction (satisfaction) beliefs regarding their writing skill. The shift between process and outcome goals appears to move the individual from a self-controlled level of competence to a fully self-regulated level of competence.

Goal setting is an important aspect of the self-regulation of learning since goals influence the learner's thinking, emotions and actions. Goals can energise learners and guide their action, with pro-active choices being made about which activities, or learning strategies and techniques, are required to achieve their intended goals. It is important that students can make a distinction between process goals and outcome goals. Outcome goals refer to the final product of the activity, such as understanding each chapter, but process goals refer to how the final outcome goal will be reached. Process goals, such as summarising the main points in the chapter, are especially important during the early stages of learning a new topic since they allow rapid self-evaluation of whether the goal is being attained and whether any self-adaptive changes need to be made. Successful achievement of an intended goal, whether outcome or process, also increases self-efficacy beliefs and self-motivation.

Successful goal attainment requires the use of appropriate strategies. Effective learners have a small repertoire of favourite strategies that are 'tried and trusted' but underachieving learners either have a limited range of effective strategies or repeatedly use ineffective strategies (Pressley & Ghatala 1990). It is not unusual to hear many underachieving medical students state that they cannot understand the subject despite repeatedly reading their text book or lecture notes. Research that has looked at self-regulation processes during reading has identified that high-achieving readers constantly self-monitored, self-evaluated and made adaptive changes regarding their choice of strategies to ensure that these strategies were being effective for understanding the text that they were reading (Paris & Paris 2001). This research in children subsequently led to the development of a range of structured instructional approaches for reading comprehension and these approaches can be easily applied to medical education. For example, one commonly used approach concentrates on four main strategies: predicting, questioning, clarifying and summarising. This approach can be readily applied to medical education. For example, students can be instructed to initially predict what they think they will learn in a short predetermined section of the overall text, such as the main features of a clinical case of hyperthyroidism. After reading this passage of text, students can ask themselves questions to answer, such as why should there be a tachycardia or a tremor in a typical case of hyperthyroidism. These questions can be answered by looking at what they have previously read in the section of text. Students can also be instructed to identify any concepts or words that they do not understand so that they can clarify the meaning, such as by asking their tutor or looking at other learning resources. Finally, students can summarise the section to retell the main idea or key points of what was read in their own words.

Implementing and evaluating whether a chosen strategy is the most appropriate and effective is an active process for the learner. Learners who have greater self-awareness of how they are approaching a task, as well as their progress towards their intended goal, are more likely to make adaptive changes or adjustments to their strategies when confronted with challenges. Some learners always use these self-regulation processes but some use them inconsistently across different subjects and situations (Hong 1998). The extent to which students can become active, strategic learners is related to the quality of both internal and external feedback (Butler & Winne 1995). Internal feedback requires increased self-awareness during a task and this can be developed by making frequent checks on understanding what is being read, such as by focusing attention on one paragraph or section at a time. Sources of external feedback include recording progress towards a goal, such as by making a graph of their grades, or obtaining comments from tutors and other students.

Another important aspect of academic performance is the motivation of the learner. Motivation energises and directs students' behaviour. It is affected by their self-beliefs and also their beliefs about the task. Although goal-setting and attributions impact on motivated behaviours, social-cognitive theorists also place primary importance on self-motivation beliefs, such as expectancy and value (Wigfield & Eccles 2000; Zimmerman 2000). Expectancy judgements involve a person's perceptions about the skill in performing specific actions that can lead to particular outcomes. In a sense, these types of judgements involve how capable an individual believes that he or she is and whether he or she has control over themselves and a given situation. One of the most well-researched expectancy constructs is self-efficacy beliefs, which are highly specific judgements about one's capabilities to perform specific acts in a particular situation. These beliefs are highly contextualised and thus can, and often do, vary across different situations. For example, a learner may feel confident about taking exams in microbiology, but incapable of passing neuro-anatomy exams. One of the most important aspect of this belief is it is amenable to change with demonstrated successes, as increasing frequency of success on examinations

in neuro-anatomy will increase their self-efficacy beliefs in this context.

Learners' beliefs about the value of studying for a particular subject are also important for understanding their level of motivation. Students who are interested in a particular subject area and/or perceive this content area to be of high importance or value will often display more effort and engagement in learning. The motivational and attribution beliefs of underachieving learners can be identified by direct questioning and then modified by reflecting on how these beliefs can influence academic achievement and consideration of positive approaches to change these beliefs.

In conclusion, many aspects of self-regulation theory can practically inform approaches to improve academic performance in medical education. The use of self-regulation to improve academic achievement is illustrated in the following example.

Peter is a first-year medical student and has previously obtained high examination grades in most courses. However, he finds biochemistry difficult to understand and has barely passed his first test in this course. He begins to have self-doubts about his abilities, saying that he is not as smart as he once thought and that he will never pass the biochemistry test at the end of term. He tends to avoid studying biochemistry and spends a lot of time listening to his favourite pop music and texting his friends at the same time as when he occasionally reads his textbook.

How can Peter be helped to improve his academic achievement by the actions of his tutor?

In general, the tutor will seek to help Peter develop his self-efficacy that he can successfully pass these tests and to begin conversations to promote thinking about strategies before, during and after learning. In this situation, the tutor would want to challenge Peter's negative attribution (self-judgement in self-reflection phase that leads to adaptive change) that his ability and aptitude was the reason for his poor test performance in biochemistry. Such an attribution leads students to give up easily and to not try to figure out a solution to their problem. To promote strategic thinking, the tutor will get Peter to divulge some of the methods he used to learn and then to attribute his poor performance to his approach. This change in attribution is important because it helps to convey to Peter that change is possible, as long as he can learn new strategies. The tutor can also help to motivate Peter by helping him to appreciate the relevance of biochemistry in his career aspiration of becoming a cardiologist (to be used for positive self-instruction statements to motivate himself during the performance phase).

Peter is advised to concentrate on an initial short-term process goal, such as understanding the first chapter about the function of enzymes, instead of the whole textbook of biochemistry (goal setting in forethought phase). He is helped to choose a learning strategy, such as predicting what information the book chapter is going to present, frequently clarifying information that he does not understand and finally summarising what he has read by making a series of notes (task strategies in performance phase). He is encouraged to talk to himself as he uses these strategies (self-instruction in performance phase) and also to avoid any distractions, such as listening to music or testing friends (attention focusing in performance phase). The tutor also highlights the importance of checking understanding of what he has read and he is advised to take several short biochemistry self-tests, such as from a revision aid book or website (self-monitoring in performance phase), and to keep a record of his test scores (self-recording in performance phase). This self-monitoring helps Peter to make adaptive changes to his strategies.

As Peter takes additional tests and becomes more aware of the strategies that he is using to learn and take tests, the tutor encourages Peter to consider that his success (self-evaluation in self-reflection phase) is due to his use of several new strategies for studying biochemistry (attribution in self-reflection phase). As Peter begins to have more success and attributes his success to his own skills and strategy, he will likely exhibit higher levels of self-efficacy beliefs and motivation to study biochemistry (self-reaction in self-reflection phase). Peter is encouraged to continue with this new approach for the rest of the term and he is delighted to obtain a high score in the end of term biochemistry test.

Improving clinical performance

An important aspect of clinical performance is the effective use of essential basic clinical skills, such as performing a cardiac examination or obtaining a blood sample by venepuncture. Previous research has shown that self-regulation is a distinguishing characteristic between individuals who have high and low complex psycho-motor skilled performance. For example, Cleary and Zimmerman (2001) showed that prior to performance (forethought phase) students classified as experts in basketball free-throws made more specific goals and used more technique-focused strategies. During a practice session and following missed free-throw attempts, the experts attributed these misses directly to the shooting strategies that they were using ('knee bend', 'elbow straight'). In addition to higher level of self-efficacy regarding their ability to successfully shoot free-throws, experts who made strategic attributions following missed attempts were more likely to report modifying these strategies or shooting techniques prior to the next shots. The authors also highlight the cyclical relationship among several self-regulation processes, with goal setting being correlated with choice of strategy and attribution self-judgements being predictive of forethought selection of strategy during subsequent efforts to improve performance.

Recently, Cleary and Sandars (2011) used a case study approach to qualitatively examine the self-regulation processes of medical students who successfully performed venepuncture (blood taking) on their first attempt and those who needed several attempts to draw blood. Participants who were successful at this task exhibited strategic thinking throughout each of the three cyclical phases, whereas those who were not successful tended to focus on outcomes or non-processes. Specifically, participants who did the venepuncture successfully on their first attempt, reported setting process goals and plans, monitored the process and their venepuncture techniques used during the task (performance phase) and

evaluated their level of success or satisfaction with their performance using process or technique related criteria. In contrast, the qualitative profile of strugglers involved more of a focus on outcomes rather than the processes or strategies instrumental to successful task performance.

Important to medical educationalists is that specific training to develop self-regulation processes can improve complex psycho-motor skilled performance. Research has focused on instructing participants to engage in specific processes in the cyclical model, in particular, goal setting (forethought phase) and self-recording (performance phase). Zimmerman and Kitsantas (1996) investigated the effects of goal setting and self-recording on dart-throwing by instructing participants to set process goals and to self-record any steps in the instructions that they had missed. This training increased dart-throwing skill, self-efficacy and self-satisfaction. Overall, goal setting and self-recording accounted for 71% of the students dart-throwing proficiency. This suggests that these processes are very influential in increasing skill acquisition. Similarly, Kitsantas and Zimmerman (1998) also experimentally investigated the effects of self-evaluative recording training in the use of dart-throwing strategies and techniques during practice. Individuals who engaged in self-evaluative recording made more strategic attributions following poor dart-throwing attempts than those who did not engage in this type of recording. From a self-regulation and motivation perspective, making strategic attributions is highly beneficial because strategy use can be modified and adapted, thus cultivating beliefs of agency and control in students.

Research has also investigated the additive effects of training individuals in each phase of the cyclical process on their basketball free-throw skill (Cleary et al. 2006). Participants who received training in the full cyclical loop were instructed to set process goals (forethought phase) to self-record their strategy use during a practice shooting session (performance phase), and to link missed free-throws to their shooting form (self-reflection). Participants were randomly assigned to either three-phase self-regulation instruction, two-phase instruction (forethought, performance), one-phase training (forethought) or no instruction (control group). Individuals who received training in all three or two phases (forethought and performance), displayed more accurate free-throw shooting, made more strategic causal attributions and reported more technique specific adaptive inferences than those who only received one phase of training or no regulation training. The advantage of cyclical training was further established as the three-phase training group used more process-oriented criteria to make self-judgements about performance than all other groups (Cleary et al. 2006).

An understanding of research examining self-regulation processes in athletic and complex psycho-motor skilled performance may be applicable to the structured identification and remediation of clinical skills performance in medical education. For example, students who are underachieving can be observed during an Objective Structured Clinical Examination (OSCE) to identify specific aspects of their self-regulation processes during actual performance. Subsequently, this can be followed by structured remediation in which the students are trained to set process goals, self-record their performance and to make adaptive adjustments to their strategies and motivational beliefs. The use of self-regulation to improve clinical performance is illustrated in the following example.

Paul is a second-year family medicine resident who has failed most of the clinical assessments that he has taken during the first year. He says that he cannot understand why he has failed his clinical assessments since he feels that he knows what to do.

How can Paul be helped to improve his clinical performance by the actions of his tutor?

The tutor decides to employ a diagnostic technique called Self-Regulated Learning Microanalysis as Paul engages in structured clinical activities. With this assessment approach, a tutor can identify the quality of the cyclical self-regulation processes (i.e. all three phases) exhibited by Paul during a simulated clinical encounter. The primary objective of micro-analysis is to ask specific regulatory questions as a person is engaging in some authentic task. The OSCE is an ideal method to employ microanalysis because students are expected to demonstrate specific behaviours or skills as they complete the clinical tasks. Ultimately, the tutor is interested in examining Paul's regulatory thoughts and actions as he performs this task. In this example, the tutor arranges for Paul to perform a cardiac examination with a simulated patient who has a heart murmur.

(a) Identification problems with key self-regulation processes

Questions before taking the OSCE:

These questions are designed to identify the use of key self-regulation processes in the forethought phase. These questions enquire about self-efficacy beliefs for the task, the selection of process goals and the selection of specific strategies and techniques related to the task. The main focus of these questions is to identify the specific approach that Paul intends to use to ensure that the task is successfully completed. Examples of the specific strategies and techniques include the need to focus attention on the task, block out any distractions, visualise the steps in the examination and positive self-talk during the performance to increase self-efficacy beliefs.

- How sure are you that you can perform an adequate cardiac examination on this patient? (to assess self-efficacy beliefs)
- Do you have a goal(s) in mind before you begin the cardiac examination? If so, what is(are) (it)they? (to assess process or outcome goal selection)
- What do you need to do to successfully perform the cardiac examination? (to assess the selection of specific strategies and technique)

Questions during the performance of the OSCE:

These questions are designed to identify the use of key self-regulation processes during their engagement in a clinical task, such as listening to the heart sounds. These questions would involve examining Paul's awareness about whether his choice of strategy to perform the task is successful or not and/or his use of self-control strategies to manage how well he performs

the task. An example of a metacognitive monitoring question would be:

- Do you think you have performed a flawless process thus far or have you made any mistakes? (to assess self-monitoring of performance)

Questions after the OSCE performance:

Questions administered after performance are designed to identify the quality of students' self-reflection processes, such as attributions, especially at major points of challenge. In this case, the reflection questions would target Paul's perceptions as to the reasons why he was successful or not in listening to and interpreting the heart sounds. Another reflection question involves targeting Paul's perceptions about what things he needs to do to improve his performance on this task, such as change in examination technique or reinforcement of motivational beliefs.

- If Paul fails to interpret the heart sounds, the tutor stops him and asks:

(a) Why do you think that you could not interpret the heart sounds? (to assess the attributions for unsuccessful performance)
(b) What do you need to do to successfully on your next attempt to interpret the heart sounds? (to assess the self-adaptive changes required for successful performance)

- If the resident successfully interprets the heart sounds, the tutor can stop Paul and ask:

You successfully interpreted the heart sounds. Why do you think that you were successful on your first attempt? (to assess the attributions for successful performance)

(b) Remediation of problems with key self-regulation processes to improve clinical performance

The microanalytic assessment process is designed to reveal deficiencies in Paul's regulatory processes during the cardiac exam. For example, Paul may set very general goals, such as, to do my best, and exhibit poor knowledge or use of strategies to perform the task, such as not using imagery or using positive self-talk. It might also be revealed that Paul possesses minimal awareness of how he performs the task (monitoring) and expresses that his struggles are most likely due to the difficulty of the exam and teacher skill (attributions). These maladaptive regulatory thoughts can be modified through self-regulation feedback and training. For example, Paul can be taught the importance of setting process goals prior to beginning the task, such as identifying whether the murmur is systolic or diastolic, and then developing a specific plan on how he will execute all the required steps of the diagnostic strategy. Paul can also be taught to use self-talk during the performance of this task to help him focus his attention and to encourage and reinforce himself to promote higher levels of self-efficacy (Hardy 2006).

General instructional approaches

A variety of instructional approaches have been described for the development of self-regulation processes but there are several common features (Ertmer & Newby 1998). The key feature of all these approaches is that they offer the learner more than a range of simple strategies. They provide an opportunity for the learner to know when to use a particular strategy and why it should be used, to self-monitor the use of the strategy to check whether it is effective and to make self-adaptive changes to both their use of strategy but also develop a strong belief that they can achieve a task using the most appropriate strategy. An important role is that of the tutor who can integrate self-regulation processes into their daily interactions with learners. 'Learning to learn' courses and the use of self-regulation focused feedback also appear to be useful in helping learners to become more self-regulated in their approach to learning. These general principles are relevant and potentially useful in medical education.

The role of the tutor. Self-regulation is a process that focuses on the thoughts, emotions and actions of an individual learner. However, this process is significantly influenced by the actions and feedback provided by others, especially a skilled tutor. The overall aim for the training of self-regulation for lifelong learners is to empower and develop their personal control, often called agency, of their internal motivation and use of strategies (Bandura 1989). Educational activities should enable learners to become more conscious and aware of how their thoughts and emotions influence their performance, to develop positive motivational beliefs and adaptive attributions and to develop their skills to adapt a variety of strategies to achieve success.

It is useful to consider the overall role of the tutor in greater detail. Paris and Paris (2001) provide a useful review of the classroom applications of research on self-regulated learning but the principles are also relevant to medical education for both the development of academic and clinical skills. These include:

- Providing opportunities for the learner to observe the performance of a skilled individual, such as a tutor. This is especially powerful if verbal explanations of the use of the key self-regulation processes are given by the performer.
- Engaging the learner in situations in which key self-regulation processes are required, such as reading a complex article or making a diagnostic decision, and coaching the learner to use the self-regulation processes in a strategic and adaptive way.
- Encouraging learners to become more aware of their use of self-regulation processes during initial learning of a new task or when trouble-shooting underachievement, either academic or clinical, so that the leaner can become more self-reflective and self-adaptive. For example, if a learner fails a task, he or she should relate one's struggles to insufficient levels of effort or ineffective use of strategy.

Learning to learn courses. The value of 'learning to learn' courses has been shown in several research studies with college students (Hofer & Yu 2003) and also in a pilot project

(Pause 2 Learn) with first-year medical students (Sandars 2010). The students initially rated themselves on various aspects of their learning approach by answering the 81 questions of the Motivated Strategies for Learning Questionnaire (MSLQ; see Figure 2). The implications of both the individual and group scores for each domain prompted group discussion over the next four tutorials. A collection of specific handouts containing hints on how to improve the various self-regulation processes were offered to all students. Finally, each student completed a self-reflection exercise and an action plan for his or her personal development of their self-regulation processes. Students agreed that the course had given them new information about the way that they learn, that completing the questionnaire helped them to identify their approach to learning, that the opportunity to discuss their approach to learning in the group was useful, and that the handouts on study strategies were useful.

Feedback focused on self-regulation processes

Research has consistently shown that many individuals, including medical students and doctors, are inaccurate in their own judgements about their knowledge, skills and performance (Davis et al. 2006; Hacker et al. 2008). Most students tend to overestimate their skills, which unfortunately can have a negative effect on their selection of and use of strategies to achieve a task. Learners who struggle the most are often those have the greatest discrepancy between perceived competence and their actual performance. In addition, these types of students often do not take corrective measures when they correctly self-assess poor performance. To engage in effective adaptation, these types of learners either need to be able to generate informative internal feedback or to be given external feedback by tutors or teachers. In short, feedback is an essential and integral component of the self-regulation of learning since it provides an opportunity for the learner to make adaptive changes to their use of key self-regulation processes (Butler & Winne 1995).

Internal feedback, or information that is produced by the individual, typically occurs through a self-monitoring process that can be developed through training (Hartman 2001). An interesting approach is the self-directed use of structured workbooks that allow learners to self-monitor their performance and also to record their adaptive changes to study strategies and techniques (Nietfeld et al. 2006). External feedback, such as comments made by others about the skills or task performance of a student, can be a powerful reality check that highlights the discrepancy between perceived and actual performance. This feedback can be obtained from teachers, tutors and peers. When provided effectively, external feedback can be a very important component of self-regulation because it directs a learner's attention on essential requirements of a task or the behaviours or processes needed to adapt or correct mistakes. The overall theme about external feedback is that it is critical for effective self-regulation, but there must be careful consideration of how it is given to students. Personal experience suggests that external feedback is often related to specific content or general task performance. However, feedback related to process is most relevant in enhancing self-regulation processes but appears to be rarely given.

In conclusion, self-regulation theory provides a systematic approach to both understand and provide structured training that is required to enhance learning and performance. Although many current approaches to teaching and learning in medical education apply some of the aspects of self-regulation theory, the extensive research evidence in children and college students suggests that it may be highly effective in both undergraduate and postgraduate medical education.

Future developments and applications

We recognise that many aspects of self-regulation theory are to some extent already integrated into medical education but we

The MSLQ is an 81 item self-report questionnaire for college students:

- Motivation scale (31 items) - intrinsic goal orientation, extrinsic goal orientation, task value, control of l earning beliefs, self-efficacy for learning and performance, test anxiety
- Learning scale (31 items) – use of different strategies (rehearsal, elaboration, organisation, critical thinking) and self-regulation processes
- Resource management scale (19 items) – time and study environment, effort regulation, peer learning, help seeking

Copies of the MSLQ can be obtained from Combined Program in Education and Psychology (CPEP) cpep@umich.edu

Figure 2. Main components of the MSLQ.

consider that a more explicit and systematic application of self-regulation theory has the potential to enhance teaching and learning for both undergraduate and postgraduate learners. We recommend that the main areas for the future development and applications of self-regulation theory in medical education are to identify opportunities for further integration into existing curricula, to inform future development of e-learning and for the structured identification and remediation of underachievement, including problems related to professional behaviour. Currently, there has been little research in these areas but we hope that readers will be stimulated to consider further implementation and evaluation of the proposed applications in medical education, both undergraduate and postgraduate.

Integration into existing curricula

Many undergraduate and postgraduate learners in medical education naturally exhibit adaptive self-regulation processes. However, it is likely that one or more of these processes may be under-developed in any given student and that for some students there may be quite a large number of deficiencies. These learners will benefit from specific self-regulation training so that their educational potential can be maximised.

Problem-based learning has been widely introduced in an attempt to develop the learning processes of students using problematic situations as a trigger to seek new information. There is overlap between the concepts of problem-based learning and self-regulation, with both having an emphasis on student control over the learning process and the use of a learning approach that requires the setting of goals and reflecting on performance (Loyens et al. 2008). However, the delivery of problem-based learning does not have a strong focus on the development of self-regulation processes (Moust et al. 2005). Key aspects of self-regulation can be specifically introduced in problem-based curricula, especially if the tutor is aware that students are underachieving. Examples of these interventions include those related to setting process goals, selecting a strategy to achieve these goals, self-monitoring and making adaptive changes that are related to self-beliefs or selection of appropriate strategies or techniques. An important aspect is that the tutors focus on how the students are using the various key self-regulation processes instead of a focus on the steps in problem-based learning.

We believe that medical education could be enhanced by infusing self-regulation principles into the delivery of the curriculum. As discussed in the previous chapter, tutors could act as role models and verbalise their use of key self-regulation processes during their academic or clinical performance. Tutors could also provide strategic and process feedback to learners with a focus on strategy use and self-regulation processes. Feedback about a learner's use of cyclical self-regulation processes (Figure 3) can be generated from context-specific assessment techniques, such as think-aloud or self-regulation microanalysis. Students could also be helped by implementing separate 'learn to learn' courses or using a peer mentoring approach, such as reciprocal teaching, in which learners mentor each other using a structured approach to understanding text. This approach has been extensively used and studied in developing comprehension of written materials (Hart & Speece 1998).

Forethought Phase

- What is the nature of the task?
- What is my goal?
- What kind of information and strategies do I need?
- How much time and resources will I need?
- What is my motivation?
- Do I need to modify the environment?

Performance Phase

- Do I have a clear understanding of what I am doing?
- Does the task make sense?
- Am I reaching my goals?
- Do I need to make changes?
- Do I need to modify my thoughts /emotions?
- Do I need to modify the environment?

Self-reflection Phase

- Have I reached my goal?
- What worked?
- What didn't work?
- Would I do things differently next time?
- What is the impact on my motivation?

Figure 3. Questions about the key self-regulation processes.

Development of e-learning

There has been increasing interest in the use of self-regulation to understand student success in online courses and also to inform instructional design (Artino 2008). Extensive use of instructional scaffolding, such as the use of note-taking and self-monitoring tools, can provide effective online instruction but require substantial development. However, simpler approaches can be effective. For example, a short training module on how to use self-regulation processes prior to engaging in online learning (Azevedo & Cromley 2004) or the use of a trained facilitator to develop self-regulation skills of online learners whilst participating in a module has been shown to impact learning (Azevedo et al. 2008). Further research in this area of interest is recommended.

Identification and remediation of underachievement

An increasing concern to all medical educators is the small, yet significant, number of learners who are underachieving and not reaching their potential (Hauer et al. 2009).

These 'strugglers' are a heterogeneous group and often have a complex mix of psychological and social problems in addition to problems with both academic and clinical achievements. Academic underachievement is important in the earlier years of undergraduate medical education and has been discussed previously in this Guide. Clinical underperformance is of increasing concern to both medical educators and healthcare providers because of the impact on patient safety. Most current approaches to remediation do not appear to have a clear theoretical basis and mainly consist of general support and providing opportunities to repeatedly practice clinical skills (Hauer et al. 2009). An exciting potential application of self-regulation theory is the use of Self-Regulated Learning-Microanalytic Assessment and Training (SRL-MAT) for the systematic approach to the identification and remediation of clinical performance problems (Durning et al. 2011). This approach is similar to the example of improving clinical performance in the previous chapter.

There is also increasing concern about 'professionalism' in both undergraduate and postgraduate medical education. This concept is nebulous but can be considered to be a certain range of behaviours that are expected of professionals, such as caring, compassion and commitment. Recent research into the personality architecture that shapes an individual's enduring motivation and personality has highlighted the importance of self-regulation processes in determining how an individual will express these factors as observable behaviour (Kuhl et al. 2006) A simple and practical approach is for a tutor to increase the discrepancy between the perceived and actual performance (as derived from external standards) to enable the individual to self-monitor and make self-adaptive changes. The potential use of self-regulation to improve professional behaviour is illustrated in the following hypothetical example.

Sam is a final year medical student and there have been several complaints about his 'unprofessional' behaviour. Patients and nurses have noted that he is abrupt in consultations and cuts off patients talking about their problems. Sam does not appear to be perturbed by these allegations and states that there are no problems with his consultation skills.

How can Sam be helped to improve his professional behaviour by the actions of his tutor?

The tutor arranges for Sam to take part in a consultation with a simulated patient and he uses a structured approach to identify key self-regulation processes.

Sam is asked to estimate how sure that he is going to achieve a 'good' consultation on this occasion and he states one hundred per cent (to assess self-efficacy beliefs in the forethought self-regulation phase). He has no clear goal for this consultation except that he wants a 'good' consultation (to assess goal-setting in the forethought self-regulation phase) and he also has no specific strategy or technique other than 'talking to the patient' (to assess choice of strategy or technique in the forethought self-regulation phase).

At the end of the consultation, both Sam and the patient are interviewed. The simulated patient expresses dissatisfaction with the present consultation with Sam, primarily because Sam exhibited a lack of empathy and a poor awareness of the patient's emotional distress, as shown by non-verbal behaviours and gestures. Interestingly, Sam did not accurately observe these behaviours (his self-monitoring in the performance self-regulation phase) and thus reported to be completely satisfied with his overall performance in the observed consultation (his self-assessment of performance in the performance self-regulation phase). It is apparent that by the end of the consultation, Sam has no clear criteria to assess how well he had performed (to assess self-evaluation in the self-reflection phase) and no plans to improve his performance next time (to assess the need to make adaptive changes in the self-reflection phase).

The main educational and remedial action of the tutor is to highlight the discrepancy between the perceived and actual performance. This can be achieved by providing external feedback from either the tutor or the simulated patient but a more powerful approach is to increase self-evaluation by ensuring that Sam observes and records the non-verbal behaviour of the patient at frequent intervals during a series of further real or simulated consultations. Subsequently, Sam is reviewed by the tutor. The tutor notes that Sam's score for his self-satisfaction of a consultation falls and that he has also become increasingly aware of his need to notice emotional distress. The tutor discusses the importance of self-awareness and makes the link between these changed parameters and the use of specific strategies or techniques by Sam. This is an important learning experience for Sam since he now realises that his professional behaviour is dependent on self-regulation processes that are under his personal control.

In conclusion, there are exciting future directions and applications of self-regulation theory in both undergraduate and postgraduate medical education, including integration with existing curricula and the structured identification and remediation of academic underachievement and problems with clinical performance. Further research into the role of self-regulation and the cognitive and emotional aspects of professionalism, including motives, self-control and temperament, is recommended. An important area for further research is whether there are gender and cultural differences in key self-regulation processes in medical education. There may be differences that suggest females are more sophisticated in their use of self-regulatory processes but this could be due to gender biases in the self-report measures used in research (Torrano & Torres 2004). Most research has also been performed in learners from Western cultures (USA, Canada and Europe) and it is uncertain whether the evidence about self-regulation processes can be generalised to learners from other cultures where there are different values associated with individual and social support of learning.

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