Learning Style	Traits
Active	Tends to retain and understand information by doing something with it
Reflective	Prefers to think about information quietly
Sensing	Likes learning facts
Intuitive	Prefers discovering possibilities and relationships
Visual	Remembers best what is seen
Verbal	Learns more from words–written and spoken explanations
Sequential	Learns best with step-by-step explanations
Global	Tends to learn in large jumps

Figure 3-15. *Some of the different traits utilized by each learning style.*

Visual, Auditory Kinesthetic Learners

One of the most popular learning styles is based on the three main sensory receptors: vision, hearing, and touch. These are called visual, auditory, and kinesthetic learning styles (VAK). *[Figure 3-16]* Research in this area dates back to the early 20th century and the concepts were developed over many years by psychologists and teaching specialists. Others have augmented the VAK model with the addition of R for "reading" (VARK), or the addition of T for "tactile" (VAKT), or even a combination of the terms for VARKT.

Learning Style	Traits	Teaching Tips
Visual	Seeing, reading	Use graphs, charts,videos.
Auditory	Hearing, speaking	Have learner verbalize questions.
Kinesthetic	Touching, doing	Use demonstrations of skills.

Figure 3-16. *Visual, auditory, and kinesthetic learning styles (VAK).*

Learners generally use all three styles to receive information, but one of these three ways of receiving information is dominant. Once again, the dominant style of receiving information is the best way for a person to learn new information, but this style may not be the same for every task. The learner may use one style of learning or a combination of styles depending on the task.

Visual learners rely on seeing information. They learn best if a major component of the lesson is something they can see, and work best with printed and graphic materials, visual displays including diagrams, illustrated text books, overhead presentations, videos, flip charts, and hand-outs. They store information in their brains as pictures or images. They like to take extensive notes. Statistically, most people are visual learners.

Auditory learners transfer knowledge through listening and speaking. These learners need an oral component to the lesson such as verbal instructions. These learners have excellent listening skills and remember what was discussed over what was seen. They are better at verbally explaining than at writing. Since auditory learners prefer to listen to material, they are not good note takers.

Kinesthetic learners process and store information through physical experience such as touching, manipulating, using, or doing. They like to move around while trying to solve a problem and learn best when the material being taught involves hands-on practical experiences. Their concentration tends to wander when there is no external stimulation. They also learn from demonstration by watching carefully, then imagining or mirroring the demonstrator's movements.

Learners may prefer one of these three learning styles over another, but most employ all three depending on the material being taught. For example, when Beverly makes her first landing with Bill guiding her attempt, she employs visual, auditory, and kinesthetic learning. As the aircraft enters downwind, Beverly uses visual cues to recognize the airport and landing strip as she lines the aircraft up to land. As Bill talks her through the procedures, Beverly is using her auditory learning skills to learn how to land the aircraft. Finally, she needs to use kinesthetic skills to perform the actual landing.

Remember, good learners are capable of processing information in a variety of ways. The key to meeting individual needs is to ensure a variety of learning styles are addressed in every lesson.

Superlinks

In a theory proposed by Ricki Linksman, the learning style ideas discussed in the preceding paragraphs have been melded into a concept based on the VAKT learning styles plus brain hemisphere preference. This "superlink," as she calls it, is the easiest way for a learner to process information in order to understand, remember, and retain it. Matching visual, auditory, kinesthetic, and tactile with right- and left-brain research, Linksman created eight superlinks: visual left-brain, visual right-brain, auditory left-brain, auditory right-brain, tactile left-brain, tactile right-brain, kinesthetic left-brain, and kinesthetic right-brain. These superlinks accelerate learning by targeting the best way a person learns.

Summary

As mentioned earlier, there are many models of how people learn. Some models identify styles or approaches that are easily recognized such as collaborative, sharing learners who enjoy working with others, versus competitive learners who are grade conscious and feel they should do better than their peers. Participant learners normally have a desire to learn and enjoy attending class, and avoidant learners do not take part in class activities and have little interest in learning.

The environment also influences learning style. In real life, most learners find it necessary to adapt to a traditional style-learning environment provided by a school, university, or other educational/training establishment. Sometimes, the learner's way of learning may or may not be compatible with his or her environment.

Instructors who recognize either the learning style or learning approach and problems associated with them are more effective teachers than those who do not. Also, these instructors are prepared to develop appropriate lesson plans and provide guidance, counseling, or other advisory services, as required.

Acquiring Skill Knowledge

An aviation instructor also helps a learner acquire skill knowledge, which is knowledge reflected in motor or manual skills and in cognitive or mental skills, that manifests itself in the doing of something. Thus, skill knowledge differs from declarative knowledge because the learner is not usually aware of it consciously or able to articulate the skill. Evidence of skill knowledge is gained through observations of performance. This knowledge of how to do things is based on extensive practice, which leads to the storage of skill knowledge. An everyday example of skill knowledge is the ability to ride a bicycle.

Skill knowledge is acquired slowly through related experience. For example, a maintenance individual in training who is learning to weld typically burns or cracks the metal being welded while an expert welder's work is free of such imperfections. What does the experienced welder "know" that the beginner does not? The expert welder has had many hours of practice and a knowing-is-in-the-doing ability the inexperienced welder lacks. It isn't always possible to reduce to mere words that which one knows or knows how to do.

Stages of Skill Acquisition

Individuals make their way from beginner to expert via three characteristic stages for skill acquisition (or the learning process) as follows: cognitive, associative, and automaticity. An instructor needs to recognize each stage in learner performance in order to assess progress.

Cognitive Stage

Cognitive learning has a basis in factual knowledge. Since the learner has no prior knowledge of flying, the instructor first introduces him or her to a basic skill. The learner then memorizes the steps required to perform the skill. As the learner carries out these memorized steps, he or she is often unaware of progress, or may fixate on one aspect of performance. Performing the skill at this stage typically requires all the learner's attention; distractions introduced by an instructor often cause performance to deteriorate or stop.

The best way to prepare the learner to perform a task is to provide a clear, step-by-step example. Having a model to follow permits learners to get a clear picture of each step in the sequence so they understand what is required and how to do it. In flight or maintenance training, the instructor provides the demonstration, emphasizing the steps and techniques. During classroom instruction, an outside expert may be used, either in person or in a video presentation. In any case, learners need to have a clear impression of what they are to do.

For example, Beverly enters a steep turn after increasing power by a prescribed amount and adjusting the pitch trim. She fixates on the attitude indicator as she attempts to achieve the desired bank angle. The bank angle exceeds tolerances as she struggles to correct it, making many abrupt control inputs.

Associative Stage

Even demonstrating how to do something does not result in the learner learning the skill. Practice is necessary in order for the learner to learn how to coordinate muscles with visual and tactile senses. Learning to perform various aircraft maintenance skills or flight maneuvers requires practice. Another benefit of practice is that as the learner gains proficiency in a skill, verbal instructions become more meaningful. A long, detailed explanation is confusing before the learner begins performing, whereas specific comments are more meaningful and useful after the skill has been partially mastered.

As the storage of a skill via practice continues, the learner understands how to associate individual steps in performance with likely outcomes. The learner no longer performs a series of memorized steps, but is able to assess his or her progress along the way and make adjustments in performance. Performing the skill still requires deliberate attention, but the learner is better able to deal with distractions.

For example, Beverly enters the steep turn and again struggles to achieve the desired bank angle. Still working on the bank angle, she remembers the persistent altitude control problem and glances at the altimeter. Noticing that the aircraft has descended almost 100 feet, she increases back pressure on the control and adjusts the trim slightly. She goes back to a continuing struggle with the bank angle, keeping it under control with some effort, and completes the turn 80 feet higher than started.

Automatic Response Stage

Automaticity is one of the by-products of practice. As procedures become automatic, less attention is required to carry them out, so it is possible to do other things simultaneously, or at least do other things more comfortably. By this stage, learner performance of the skill is rapid and smooth. The learner devotes much less deliberate attention to performance, and may be able to carry on a conversation or perform other tasks while performing the skill. The learner makes far fewer adjustments during his or her performance and these adjustments tend to be small. The learner may no longer be able to remember the individual steps in the procedure, or explain how to perform the skill.

For example, the learner smoothly increases power, adds back pressure on the yoke, and trims the aircraft as a turn is entered. During the turn, the instructor questions the learner on an unrelated topic. The learner answers the questions, while making two small adjustments in pitch and trim, and then rolls out of the turn with the altimeter centered on the target altitude. Noting the dramatically improved performance, the instructor asks "What are you doing differently?" The learner seems unsure and says, "I have developed a feel for it."

Knowledge of Results

In some simple skills, learners can discover their own errors quite easily. In other cases, such as learning complex aircraft maintenance skills, flight maneuvers, or flight crew duties, mistakes are not always apparent. A learner may know that something is wrong, but not know how to correct it. In any case, the instructor provides a helpful and often critical function in making certain that the learners are aware of their progress. It is perhaps as important for learners to know when they are right as when they are wrong. They should be told as soon after the performance as possible, and should not be allowed to practice mistakes. It is more difficult to unlearn a mistake, and then learn the skill correctly, than to learn correctly in the first place. One way to make learners aware of their progress is to repeat a demonstration or example and to show them the standards their performance should ultimately meet.

How to Develop Skills

Theories about how a skill evolves from the awkward and deliberate performance associated with the cognitive stage to the smooth and steady-handed performance of the automatic response stage have one thing in common: progress appears to depend on repeated practice. Making progress toward automating a skill seems to be largely a matter of performing the skill over and over again. In skill learning, the first trials are slow and coordination is lacking. Mistakes are frequent but each trial provides clues for improvement in subsequent trials. The learner modifies different aspects of the skill such as how to hold the yoke or how to weld.

How long does it take to become proficient at a skill? Studies of skill learning have demonstrated that progress tends to follow what is known as a power law of practice. This law simply states that the speed of performance of a task improves as a power of the number of times that the task is performed. The logarithm of the reaction time for a particular task decreases linearly with the logarithm of the number of practice trials taken. Qualitatively, the law simply says that practice improves performance.

The graph in *Figure 3-17* shows how the power law of practice relates the time required to perform a skill to the number of times the skill has been practiced. While it is impossible to predict how many practice trials a learner will require to develop a skill to maturity, the general shape of the power law of practice offers some clues. Learning progress proceeds at a fast pace in the beginning (when there is ample room for improvement) and tends to slow down as performance becomes more skilled. In later stages of learning, improvement is more gradual. Once the curve levels off, it may stay level for a significant period of time. Further improvement may even seem unlikely. This is called a learning plateau.

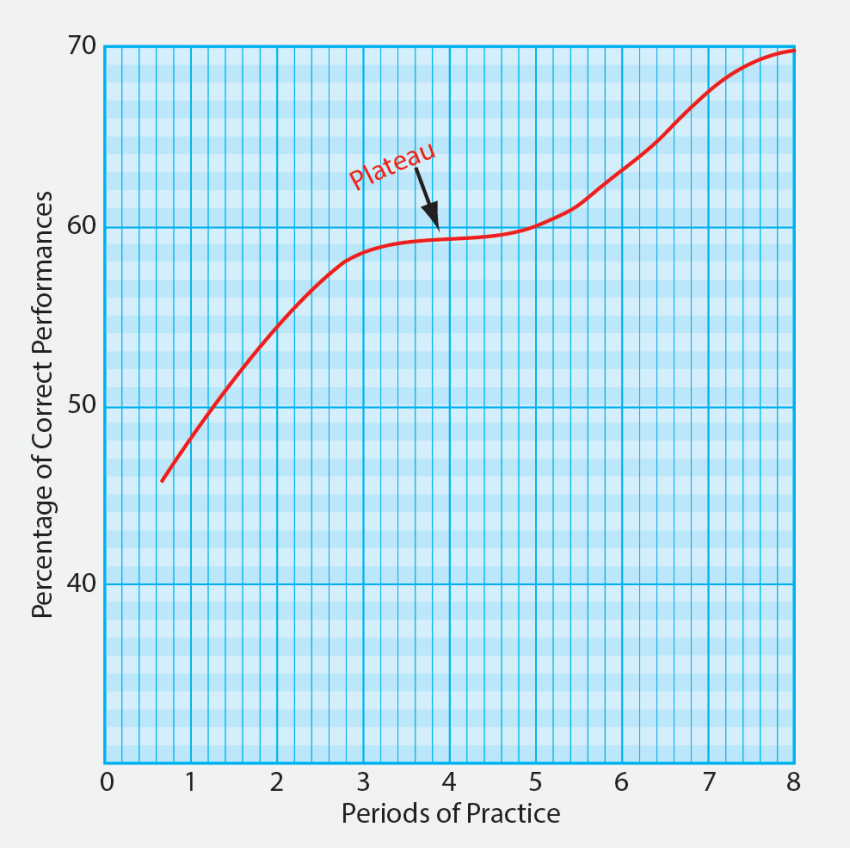

Figure 3-17. *Learners will probably experience a learning plateau at some point in their training.*

Learning Plateaus

A learning plateau may signify any number of conditions. For example, the learner may have reached capability limits, may be consolidating levels of skill, interest may have waned, or the learner may need a more efficient method for increasing progress. Keep in mind that the apparent lack of increasing proficiency does not necessarily mean that learning has ceased. When learning motor skills, a plateau, is normal and should be expected after an initial period of rapid improvement.

The instructor should prepare the learner for this situation to avert discouragement by explaining that the plateau is normal and temporary. Instructors can help learners who fall into a plateau by moving the learner to a different place in the curriculum and giving the current task a break. Instructors should also be aware that they can bring on a learning plateau by over-practice. Learning plateau problems can sometimes be alleviated also by the instructor better explaining the lesson, the reason for the lesson, and how it applies to the learner.

Types of Practice

Once a learner learns the skill, it is important to continue some practice to improve retention, but the power law of practice raises the question of whether or not there is a point at which continued practice no longer leads to improvement. Since athletic coaches, among others, are very interested in maximizing performance, much research has been done on the subject. Within the last few years, research has shown that how practice is structured makes an important impact on how well people retain what they have learned.

There are three types of practice, each of which yields particular results in acquiring skills: deliberate, blocked, and random.

Deliberate Practice

In order for a learner to gain skill knowledge on how to perform the skill automatically, he or she needs to engage in deliberate practice. This practice is aimed at a particular goal. During deliberate practice, the learner practices specific areas for improvement and receives specific feedback after practice. The feedback points out discrepancies between the actual performance and the performance goal sought. During deliberate practice, a learner focuses on eliminating these discrepancies. *[Figure 3-18]*

Figure 3-18. *A learner exhibits deliberate practice by plotting courses for his next training flight.*

Studies of skill learning suggest a learner achieves better results if distractions are avoided during deliberate practice. When feedback is needed to correct learner performance, it should be brief and explicit. Examples of individual skills for pilots are landings, stalls, steep turns, and procedure flows. Examples for maintenance technicians are correct installation of piston rings on a reciprocating engine, setting timing on an aircraft engine, and installing a tach generator.

Unlike the acquisition of knowledge, skill learning does not benefit from the instructor introducing the learner to new ideas or prompting the learner to think about old ones in different ways. On the other hand, instructors should not confuse distractions during skill learning with the legitimate use of distractions to help a learner learn how to manage his or her attention while coordinating several tasks that have been mastered to some degree.

Blocked Practice

Blocked practice is practicing the same drill until the movement becomes automatic. Doing the same task over and over leads to better short-term performance, but poorer long-term learning. It tends to fool not only the learner but the instructor into thinking the skills have been well learned. While blocked practice enhances current performance, it does not improve either concept learning or retrieval from long-term memory. *[Figure 3-19]*

Figure 3-19. *Pilot practices cross-wind landings repeatedly to improve performance.*

Random Practice

Random practice mixes up the skills to be acquired throughout the practice session. This type of practice leads to better retention because by performing a series of separate skills in a random order, the learner starts to recognize the similarities and differences of each skill which makes it more meaningful. The learner also is able to store the skill more effectively in the long-term memory. Learners get to retrieve steps and parameters from long-term memory which helps learners recognize patterns between tasks.

Blocked practice performance scores well during the actual practice when compared to random practice performance. But on a test given the next day, random practice does better than blocked practice. For long-term retention of aviation knowledge, the instructor who uses well-written SBT which encourages random practice and leads to better retention of information.

How much practice is needed to attain proficiency? In planning for learner skill acquisition, a primary consideration is the length of time devoted to practice. A beginning learner reaches a point where additional practice is not only unproductive, but may even be harmful. When this point is reached, errors increase, and motivation declines. As a learner gains experience, longer periods of practice are profitable.

Another consideration is the problem of whether to divide the practice period. Perhaps even the related instruction should be broken down into segments, or it may be advantageous to plan one continuous, integrated sequence. The answer depends on the nature of the skill. Some skills are composed of closely related steps, each dependent on the preceding one. Learning to pack a parachute is a good example. Other skills are composed of related subgroups of skills. Learning to overhaul an aircraft engine is a good example.

One way to structure practice to get the most from learning is to expose the learner to the same knowledge and skill in different contexts. For example, after practicing the short field landing in the aircraft, return to the classroom and rehearse the procedure using the toy airplane. Then, watch a video that shows a variety of back-to-back landings and have the learner describe what went right and what went wrong. Each of these methods gives the learner the chance practice the maneuver while adding new perceptions and insights to his or her skill base.

Evaluation Versus Critique

In the initial stages of skill acquisition, practical suggestions are more valuable to the learner than a grade. Early evaluation is usually teacher oriented. It provides a check on teaching effectiveness, can be used to predict learner outcomes, and can help the teacher locate special problem areas. The observations on which the evaluations are based also can identify the learner's strengths and weaknesses, a prerequisite for making constructive criticism. For additional information, refer to Chapter 6, Assessment.

As a learner practices a skill, it is important he or she perform the skill correctly and that the skill being practiced is one that needs to be developed to maturity. An instructor ensures a skill is practiced correctly by monitoring the practice and providing feedback about the skill development. The learner profits by having someone watch the performance and provide constructive criticism to help eliminate errors. Providing compliments on aspects of the skill that were performed correctly help keep the evaluation positive. Allowing the learner to critique his or her performance enhances learner-centered training.

Instructors should note learners can develop deviations from the intended method of performance at any stage of skill acquisition.

Overlearning of Knowledge

Overlearning is the continued study of a skill after initial proficiency has been achieved. Practice proceeds beyond the point at which the act can be performed with the required degree of excellence. The phenomenon of overlearning sometimes occurs when knowledge used frequently begins to take on the properties of a skill. For example, a learner's everyday knowledge about weight and balance concepts tends to center on the routine use of familiar charts found in the aircraft. Eventually, the learner's performance is characterized less by an understanding of weight and balance concepts, and more by an automatic process in which rows and columns of familiar charts give desired numbers.

In some cases, the overlearning of knowledge has the advantage of making application of knowledge more streamlined and efficient. In other cases, the development of automated routines can lead to problems. For example, a verbal checklist procedure becomes so automatic that a streamlined recitation of checklist items becomes decoupled from the thoughts and actions the checklist items are intended to trigger. In this case, the pilot or mechanic may not stop to consider each item.

The development of automated skills can impede further learning or lead to forgetting general knowledge. In one study, learner pilots and flight instructors were asked to solve weight and balance problems using charts taken from two different aircraft: (1) a small single-engine airplane they flew on a daily basis and (2) a different small single-engine airplane in which they had no experience. Test scores were surprisingly low when the charts for the unfamiliar airplane were used, and this was as true for instructors as it was for learners. The results suggest pilots had focused on developing streamlined, automatic procedures tuned to the details of the familiar aircraft charts while their ability to use their understanding of overall weight and balance concepts seemed to have diminished.

Instructors should remain aware of skills learners develop as a result of overlearning and help make sure that their actions continue to be accompanied by a use of their underlying knowledge. As a learner progresses, the key difference between knowledge and skill becomes apparent. Memorized facts about a topic that once supported the beginner's awkward performance of the skill tend to develop into deeper understanding. Skill acquisition involves learning many individual steps that eventually meld into a seemingly continuous automated process, at which point the learner has entered the procedural knowledge realm, and may no longer be consciously aware of the individual steps.

Application of Skill

The final and critical question is "Can the learner use the information received?" It is not uncommon to find that learners devote weeks and months in school learning new abilities, and then fail to apply these abilities on the job. To solve this problem, two conditions need to be present. First, the learner needs to understand the skill so well that it becomes easy, even habitual. Second, the learner should be able to recognize the types of situations where it is appropriate to use the skill. This second condition involves the question of transfer of learning, which is discussed later in this chapter.

Summary of Instructor Actions

To help learners acquire skills, the instructor should:

- Explain that the key to acquiring and improving any skill is continued practice.
- Monitor learner practice of skills and provide immediate feedback.
- Avoid conversation and other distractions when learners are practicing individual skills.
- Explain that learning plateaus are common and that continued practice leads to continued improvement.

Putting It All Together

Many skills are taught before a learner can fly an airplane or a maintenance learner can rebuild an aircraft engine. Just as practicing scales is a fundamental part of learning to play the piano, the learner does not "make music" until the ability to combine the notes in a variety of ways is acquired. For the learner pilot or technician, practicing specific skills is essential, but flying a cross-country trip or repairing a collapsed landing gear requires "putting it all together" in the right way to achieve success.

The following section looks at the challenge of learning to perform several tasks at once, dealing with distractions and interruptions, overcoming problems with fixation and inattention. It also describes the benefits of using realistic training scenarios to develop these abilities.

The Multitasking Mistake

The term multitasking is often taken for granted to mean handling several tasks at the same time. For example, when a pilot is on approach for a landing it is easy to assume that the experienced pilot is performing tasks in concurrence such as ATC communications, scanning instrumentation, and adjusting for minor deviations through the flight controls. We assume that, due to experience and practiced refinement, such skills at some point become automatic and somewhat instinctive. This belief can lead to a false sense of confidence that the routine procedure at hand is *only* routine and therefore does not require the added attention to question one's assumption that there will be no deviation in that task. *[Figure 3-20]*

Figure 3-20. *A pilot is required to perform several tasks at once during approaches and landings.*

Priorities of Task Management

It is generally impossible to look at two different things at the same time. The area of focused vision (called the fovea) is only a few degrees in span and can only be directed to one location at a time. Similarly, people cannot listen to two conversations at the same time. While both conversations fall upon the ears at once, people need to devote their attention to the comprehension of one, to the exclusion of the other.

In the flight deck, a pilot is encumbered with any number competing events, tasks, and actions that each demand the attention of the pilot. While the pilot may believe that he or she is successfully managing these many tasks at the same time, in actuality, it is difficult to process more than one thought in congruence. This is especially true when one or more tasks go beyond perceived automation and require cognitive effort. To help reduce the risk of information-processing bottlenecks, it may be necessary for the pilot to employ attention switching.

Continuously switching attention back and forth between two or more tasks is attention switching. For example, when Beverly uses a checklist to perform a preflight inspection, she continuously switches her attention between the checklist and the equipment she is inspecting. She looks at the checklist to retrieve the next step in the procedure, and then looks at the equipment to perform the step.

There is a danger in task switching. The individual may decide that one task is less of a priority than another and choose to postpone resolution of that task. In doing so, it is very easy to simply forget the deferred task completely. Or, should the pilot become momentarily distracted, then effort should be made to remember what task to return to and at what stage of resolution that task was left in. Even the act of managing such tasks is in and of itself a task.

Increased Workload, Diminished Quality

A common response to an overwhelming workload is to reduce the level of standards for quality and achievement. Preemptively evaluating an impending task list to then choose to reduce (or even remove) relatively unimportant tasks can be a safe and effective action against the stresses that often comes with overburdened workload. However, it is not always the case that individuals have the time (or cognitive discipline as referenced in Chapter 2, Human Behavior) to accurately predict what tasks should instead be focused on. Sometimes the individual (especially those inexperienced or under high stress) reverts to a reaction-based response process. This can create a negative environment that may actually induce more stress as the individual continually tries to respond to each task without an overall plan.

Learning to Task Manage

Before learners are asked to perform several tasks at once, instructors should ensure that the learner has devoted enough time to study and practice such that the individual tasks can be performed reasonably well in isolation.

Inexperience with an individual task can often hinder attempts to combine it with other tasks. For example, a learner distracted by trying to interpret unfamiliar symbols on a sectional chart inadvertently deviates from assigned attitude or heading. An instructor recognizes the need to spend more time with these skills in isolation. In this case, there is nothing about the experience of controlling the aircraft that helps learners better understand chart symbols.

Distractions and Interruptions

A distraction is an unexpected event that causes the learner's attention to be momentarily diverted. Learners need to decide whether or not a distraction warrants further attention or action on their part. Once this has been decided, the learners either turn their attention back to what they were doing, or act on the distraction.

An interruption is an unexpected event for which the learner voluntarily suspends performance of one task in order to complete a different one. Interruptions are a significant source of errors and learners need to be aware of the potential for errors caused by interruptions and develop procedures for dealing with them. A classic example is an interruption that occurs while a learner is following the steps in a written procedure or checklist. The learner puts down the checklist, deals with the interruption, and then returns to the procedure—but erroneously picks up at a later point in the procedure, omitting one or more steps.

Fixation and Inattention

Since human attention is limited in focus and highly prone to distraction, people are vulnerable to two other types of problems: fixation and inattention.

Fixation occurs when a learner becomes absorbed in performing one task to the exclusion of other tasks. Instructors see many examples of this in learner performance. Beginning instrument pilots characteristically fixate on particular instruments, attempting to control one aspect of their performance while other aspects deteriorate. Fixation on a task is often a sign that the task has not received enough practice in isolation. That is, the learner has not yet mastered the task well enough to perform it in addition to other tasks. Fixation can happen even when individual skills have been reasonably mastered, when learners have not yet learned the importance of managing their own limited attentional resources.

Inattention occurs when a learner fails to pay attention to a task that is important. Inattention is sometimes a natural by-product of fixation. Learners fixate on one task and become too busy to attend to other tasks. Inattention also happens when learners are not busy: attention may drift when they become bored or think that a task does not deserve their attention. In some cases, this type of inattention is difficult to eliminate through training and practice. For example, it is well known that humans perform poorly when placed in the role of passive monitor. Many studies have shown how performance rapidly deteriorates when humans are asked to passively monitor gauges or the progress of an automated system such as a GPS navigation computer or autopilot. Furthermore, it seems that the more reliable the system becomes, the poorer the human performance becomes at the monitoring task. The first line of defense against this type of inattention is to alert the learner to the problem, and to help develop habits that keep their attention focused.

How to Identify Fixation or Inattention Problems

One way for instructors to identify problems with fixation and inattention is to try and follow where learners look. To accomplish this, instructors can glance at a learner's eyes to try to determine where they are looking. Learners who appear to look at one instrument for an extended period of time might have a problem with fixation. Learners whose gaze is never directed toward engine instruments might have a problem with inattention.

The technique of following learner eye movements is useful, but has limitations since looking in the same direction is not the same as "seeing" what the learner sees.

Scenario-Based Training (SBT)

Research and practical experience have demonstrated the usefulness of practicing in realistic scenarios—ones that resemble the environment in which knowledge and skills are later used. Instructors should devise scenarios that allow learners to practice what they have learned. This is challenging because different learners need to practice different things at different times, and because different working environments present different practice opportunities.

What makes a good scenario? A good scenario:

- Has a clear set of objectives.
- Is tailored to the needs of the learner.
- Capitalizes on the nuances of the local environment.

For example, Bill is introducing Beverly to a low-fuel emergency. His objective at this early stage is to simply enable Beverly to recall the sorts of actions that are appropriate for a low-fuel emergency. He decides to use the classroom environment as a first practice scenario. He asks Beverly about what sorts of actions she might take if such an event would occur. She has some good ideas but he asks her to think more about before her next lesson. On her next lesson he gives her the same exercise. This time her answers are consistent and insightful. Bill decides that this scenario has served its purpose and moves on.

During their next flight, Bill's objective is having Beverly recall and carry out the steps that she was able to cite in the classroom. As they arrive at their home airport, he presents Beverly with a low-fuel scenario. He notes that she remembers much of what she was able to recall in the classroom, but amidst the excitement, has forgotten a few things. He uses the same scenario at a different airport on their next flight, and she performs admirably.

Later in her training, Bill's next objective is to enable her to recall and perform the emergency steps in concert with other piloting duties. They depart on a cross-country flight from a populated area to a remote area. While en route, Bill presents Beverly with a low-fuel emergency scenario knowing that there is only one airport nearby and that it is not easy to spot. She successfully uses her available navigational resources to locate and arrive at the airport. Upon returning home, Bill attempts to generalize her new abilities and put yet a different spin on the same problem. He presents the low-fuel scenario, taking advantage of the fact that there are eight nearby airports. All of the airports are in plain view, and she can choose one.

Each of these scenarios taught Beverly something she needed to learn next, and made good use of the surroundings and available circumstances. As these examples illustrate, there is no list of "canned" scenarios that can be used for all learners. Instructors should devise their own scenarios by considering what each learner needs to practice, and exploiting features of the local environment that allow them to do it.

The Learning Route to Expertise

What does it take to successfully orchestrate all of the knowledge and skills the learner has learned into what instructors, evaluators, and other pilots and mechanics would regard as true expertise? All evidence seems to point once again to the idea of practice. Just as the perfection of an individual skill seems to rely on repeated practice, so does the combination of knowledge and skills that make up our abilities to do the real-world job of pilot or mechanic.

How much practice does it take to become a true expert? In a study of expert performers in fields ranging from science to music to chess, one psychologist found that no performer had reached true expertise without having invested at least ten years of practice in his or her field. Experts have been found to use two tools to help them gain expertise in their field: cognitive strategies and problem-solving tactics.

Cognitive Strategies

The idea of cognitive strategies emerged over 50 years ago in the context of human information processing theory. Cognitive strategies refer to the knowledge of procedures or knowledge about how to do something in contrast with the knowledge of facts. They use the mind to solve a problem or complete a task and provide a structure for learning that actively promotes the comprehension and retention of knowledge. A cognitive strategy helps the learner develop internal procedures that enable him or her to perform higher level operations.

As learners acquire experience, they develop their own strategies for dealing with problems that arise frequently. For example, a learner develops the following strategy for avoiding inadvertent flight into instrument meteorological conditions (IMC) at night. He or she checks the weather prior to departure, obtains updates on the weather every hour, and plans to divert to an alternate destination at the first suspicion of unexpected weather ahead.

One approach to helping develop cognitive strategies is to study and identify the strategies that experts use and then teach these strategies to the learners. Expert strategies were identified by researchers who presented experts with problems to solve and asked them to think aloud as they attempted to solve the problems. These cognitive strategies can be taught to learners, usually with successful results.

Problem-Solving Tactics

Problem-solving tactics are specific actions intended to get a particular result, and this type of knowledge represents the most targeted knowledge in the expert's arsenal. For example, a learner notices how easy it is to make a mistake with a takeoff distance chart after using it several times. She notices her finger drifts upward or downward when sliding it across a row of numbers on the chart, sometimes landing on the wrong number. The learner formulates several tactics to ensure she obtains the correct figures: (1) work slowly and deliberately, (2) use a ruler, and (3) double-check the work.

But even the experts had to practice. In a study of violinists at a music academy in Berlin, researchers compared the "best" learners to those who were regarded as merely "very good." Using estimates of how many total hours each learner had spent practicing during his or her lifetime, the researchers found that the best violinists had spent an average of 7,000 hours practicing, while the very good violinists had logged about 5,000 hours. The scientific study of expertise reiterates the adage: "Practice makes perfect."

Awareness of Existence of Unknowns

An important aspect of an expert's knowledge is an awareness of what he or she does not know. This is not always the case with a learner. It's important that an instructor be aware of situations in which learners have acquired "book" knowledge, but not yet acquired the more in-depth understanding that comes from association and experience. For example, after acquiring substantial knowledge of a single-engine, two-seat training aircraft, learners should understand that a four-seat aircraft by the same manufacturer should be approached with caution and not overconfidence.

Summary of Instructor Actions

To help learners exercise their knowledge and skills in a concerted fashion, the instructor should:

- Explain the difference between normal task switching and interruption multitasking and give examples of each.
- Ensure that individual skills are reasonably well-practiced before asking learners to perform several tasks at once.
- Teach learners how to deal with distractions and interruptions and provide them with opportunities to practice.
- Point out fixation and inattention when it occurs.
- Devise scenarios that allow learners to use their knowledge and skill to solve realistic problems and make decisions.
- Explain to the learner that continued practice with the goal of improving leads to continued improvement.

Errors

Errors are a natural part of human performance. Beginners, as well as the most highly skilled experts, are vulnerable to error, and this is perhaps the most important thing to understand about error. To believe people can eliminate errors from their performance is to commit the biggest error of all. Instructors and learners alike should be prepared for occasional errors by learning about common kinds of errors, how errors can be minimized, how to learn from errors, and how to recover from errors when they are made.

Kinds of Errors

There are two kinds of errors: slips and mistakes.

Slip

A slip occurs when a person plans to do one thing, but then inadvertently does something else. Slips are errors of action. Slips can take on a variety of different forms. One of the most common forms of slips is to simply neglect to do something. Other forms of slips occur when people confuse two things that are similar. Accidentally using a manual that is similar to the one really needed is an example of this type of slip.

Other forms of slips happen when someone is asked to perform a routine procedure in a slightly different way. For example, Beverly has been assigned runway 30 for many days in a row. This morning she approaches to land and ATC assigns runway 12 instead. As she approaches the traffic pattern, she turns to enter the pattern for runway 30 out of habit.

Time pressure is another common source of slips. Studies of people performing a variety of tasks demonstrated a phenomenon called the speed-accuracy tradeoff. The more hurried one's work becomes the more slips one is likely to make.

Mistake

A mistake occurs when a person plans to do the wrong thing and is successful. Mistakes are errors of thought. Mistakes are sometimes the result of gaps or misconceptions in the learner's understanding. One type of mistake happens when a learner formulates an understanding of a phenomenon and then later encounters a situation that shows how this understanding was incorrect or incomplete. For example, overly simplistic understanding of weather frequently leads inexperienced learners into situations that are unexpected.

Experts are not immune to making mistakes, which sometimes arise from the way an expert draws upon knowledge of familiar problems and responds to them using familiar solutions. *[Figure 3-21]* Mistakes can occur when the expert categorizes a particular case incorrectly. For example, an experienced pilot may become accustomed to ignoring nuisance alerts issued by his traffic alerting system when approaching his home airport, as many aircraft on the ground turn on their transponders prior to takeoff. One night, he ignores an alert that was generated not by an aircraft on the ground, but rather by another aircraft that has turned in front of him on final approach.

Reducing Error

Although it is impossible to eliminate errors entirely, there are ways to reduce them, as described in the following paragraphs.

Learning and Practicing

The first line of defense against errors is learning and practice. Higher levels of knowledge and skill are associated with a lower frequency and magnitude of error.

Taking Time

Errors can often be reduced by working deliberately at a comfortable pace. Hurrying does not achieve the same results as faster performance that is gained by increasing one's skill through continued practice.

Checking for Errors

Another way to help avoid errors is to look actively for evidence of them. Many tasks in aviation offer a means of checking work. Learners should be encouraged to look for new ways of checking their work.

Figure 3-21. *Other mistakes arise under pressure. For example, a technician or pilot might perform a cursory inspection of an aircraft to save time, only to have a problem manifest itself later.*

Using Reminders

Errors are reduced when visible reminders are present and actively used. Checklists and other published procedures are examples of reminders. Many aircraft instruments such as heading indicators offer bugs that can be used to remind the pilot about assigned headings and courses and some may also prompt altitudes and airspeeds. Mechanics and pilots alike can use notepads to jot down reminders or information that should otherwise be committed to memory.

Developing Routines

The use of standardized procedures for routine tasks is widely known to help reduce error. Even when a checklist procedure is unavailable or impractical, learners can help reduce the occurrence of error by adopting standardized procedures.

Raising Awareness

Another line of defense against errors is to raise one's awareness when operating in conditions under which errors are known to happen (e.g., changes in routine, time pressure), or in conditions under which defenses against errors have been compromised (e.g., fatigue, lack of recent practice).

Error Recovery

Given that the occasional error is inevitable, it is a worthwhile exercise to practice recovering from commonly made errors, or those that pose serious consequences. All flight learners need to learn and practice a lost procedure to ensure that they can recover from the situation in which they have lost their way. It is useful to devote the same sort of preparation to other common learner errors.

Learning from Error

Error can be a valuable learning resource. Learners naturally make errors, which instructors can utilize in training to help while being careful not to let the individual practice doing the wrong thing. When a learner makes an error, it is useful to ask them to consider why the error happened, and what could be done differently to prevent the error from happening again in the future. In some cases, errors are slips that simply reveal the need for more practice. In other cases, errors point to aspects of learner methods or habits that might be improved. For example, beginning instrument flight learners commonly make errors when managing two communications radios, each with an active and standby frequency. When the same learners understand each radio's specific purpose (e.g., ATIS, ground, tower frequencies), error rates often drop quickly.

Instructors and learners should be aware of a natural human tendency to resist learning from errors. That is, there is a tendency to "explain away" errors, dismissing them as one-time events that will likely never happen again. The same phenomenon occurs when observing errors made by others. Reading an accident or incident report, it is easy to spot where a pilot or mechanic made an error and regard the error as something that could never happen to the reader. It is important to note that this type of bias is not necessarily the result of ego or overconfidence; rather, it is something to which we are all susceptible. Psychologist Baruch Fischoff studied hindsight explanations given by people who were presented with descriptions of situations and their ultimate outcomes. When asked to provide explanations for events that had already occurred and for which the outcome was known, people explained that the outcomes were "obvious" and "predictable." When the same events without the outcomes were presented to a second group, peoples' prediction of the outcome was no better than chance guessing. The study nicely illustrates the popular adage that "hindsight is 20/20."

Summary of Instructor Actions

To help learners learn from errors they make and be prepared for them in the future, an instructor should:

- Explain that pilots and mechanics at all levels of skill and experience make occasional errors.
- Explain that the magnitude and frequency of errors tend to decrease as skill and experience increases.
- Explain the difference between slips and mistakes and provide examples of each.
- Explain ways in which the learner can help minimize errors.
- Allow the learner to practice recovering from common errors.
- Point out errors when they occur and ask the learner to explain why they occurred.

Memory

Memory is the vital link between the learner learning/retaining information and the cognitive process of applying what is learned. It is the ability of people and other organisms to encode (initial perception and registration of information), store (retention of encoded information over time), and retrieve (processes involved in using stored information) information. *[Figure 3-22]* When a person successfully recalls a past experience (or skill), information about the experience has been encoded, stored, and retrieved.

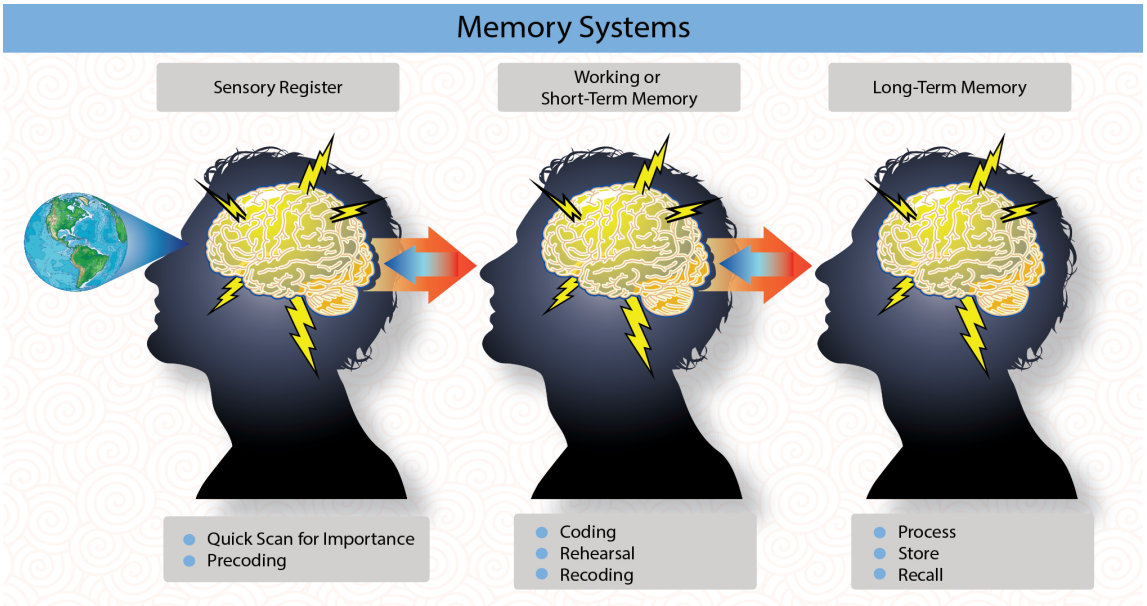

Figure 3-22. *Information processing within the sensory register, working on short-term memory, and long-term memory includes complex coding, sorting, storing, and recall functions.*

Although there is no universal agreement of how memory works, a widely accepted model has three components: sensory memory, short-term memory (STM), and long-term memory (LTM).

Sensory Memory

Sensory memory is the part of the memory system that receives initial stimuli from the environment and processes them according to the individual's preconceived concept of what is important. Other factors can influence the reception of information by sensory memory. For example, if the input is dramatic and impacts more than one of the five senses, that information is more likely to make an impression. The sensory memory processes stimuli from the environment within seconds, discards what is considered extraneous, and processes what is determined by the individual to be relevant. This is a selective process where the sensory register is set to recognize certain stimuli and immediately transmit them to the STM for action. The process is called precoding. An example of sensory precoding is recognition of a fire alarm. No matter what is happening at the time, when the sensory register detects a fire alarm, the working memory is immediately made aware of the alarm and preset responses begin to take place. Sensory memory is capable of retaining information for only a very short period of time and within seconds the relevant information is passed to the STM.

Short-Term Memory (STM)

Short-term memory is the part of the memory system where information is stored for roughly 30 seconds, after which it may rapidly fade or be consolidated into long-term memory, depending on the individual's priorities. Several common steps help retention in STM. These include rehearsal or repetition of the information and sorting or categorization into systematic chunks. The sorting process is usually called coding or chunking. A key limitation of STM is that it takes 5–10 seconds to properly code information and if the coding process is interrupted, that information is easily lost since it is stored for only 30 seconds. The goal of the STM is to put the information to immediate use.

STM is not only time-limited, it also has limited capacity, usually about seven bits or chunks of information. A seven-digit telephone number is an example. As indicated, the time limitation may be overcome by rehearsal. This means learning the information by a rote memorization process. Of course, rote memorization is subject to imperfections in both the duration of recall and in its accuracy. The coding process is more useful in a learning situation. In addition, the coding process may involve recoding to adjust the information to individual experiences. This is when actual learning begins to take place. Therefore, recoding may be described as a process of relating incoming information to concepts or knowledge already in memory.

Brain research has led to the conclusion that STM resembles the control tower of a major airport and is responsible for scheduling and coordinating all incoming and outgoing flights. STM has three basic operations: iconic memory, acoustic memory, and working memory. Iconic memory is the brief sensory memory of visual images. Acoustic memory is the encoded memory of a brief sound memory or the ability to hold sounds in STM. Of the two, acoustic memory can be held longer than iconic memory. Working memory is an active process to keep information until it is put to use (think of a phone number repeated until used). It is useful in remembering a spoken sentence or a string of digits.

Also called "scratch-pad" memory, working memory is of short duration and has limited capacity. It simultaneously stores and manipulates information. The goal of the working memory is not really to move the information from STM to LTM, but merely put the information to immediate use.

STM retention makes information available long enough for it to be rehearsed. For example, if the learner repeats the number to himself, it can be transferred to some sort of longer term storage. To retain information for extended periods of time, it needs to be transferred from STM to LTM. This process involves encoding or consolidation of information into LTM where it can then be retrieved.

Long-Term Memory (LTM)

LTM is relatively permanent storage of unlimited information, and it is possible for memories in LTM to remain there for a lifetime. What is stored in LTM affects a person's perceptions of the world and affects what information in the environment is noticed. Information that passes from STM to LTM typically has some significance attached to it. For example, imagine how difficult it would be for a pilot to forget the first day he or she soloed. This is a significant day in any pilot's training, so when the information was processed, significance was attached to it, the information was deemed important, and it was transferred into LTM.

There appear to be other reasons information is transferred to LTM because the average human brain stores numerous insignificant facts. One explanation is repetition; people tend to remember things the more they are rehearsed. Information also ends up in LTM because it is somehow attached to something significant. A person may remember the color of the clothing of the recipient of a wedding proposal. The color of the clothing plays no important role, but is attached to the memory of the experience.

For the stored information to be useful, some special effort was expended during the encoding or consolidation of information in STM. The encoding should provide meaning and connections between old and new information. If initial encoding is not properly accomplished, recall is distorted and it may be impossible. The more effective the encoding process, the easier the recall. However, it should be noted that the LTM is a reconstruction, not a pure recall of information or events. It is also subject to limitations, such as time, biases, and, in many cases, personal inaccuracies. This is one reason why two people who view the same event often have totally different recollections. Memory also applies to psychomotor skills. For example, with practice, a tennis player may be able to serve a tennis ball at a high rate of speed and with accuracy. This may be accomplished with very little thought. For a pilot, the ability to instinctively perform certain maneuvers or tasks that require manual dexterity and precision, provides obvious benefits. For example, it allows the pilot more time to concentrate on other essential duties such as navigation, communications with ATC facilities, and visual scanning for other aircraft.

Information in LTM is stored in interrelated networks of schemas which are the cognitive frameworks that help people organize and interpret information. Schemas guide recognition and understanding of new information by providing expectations about what should occur. Since LTM is organized into schemas, instructors should consciously look for ways to make training relevant and meaningful enough for the learner to transfer new information to LTM. This can be accomplished by activating existing schemas before presenting new information. For example, a brief review of the previous lesson via discussion, video, questions, etc.

Remembering What Has Been Learned

The moment people learn something new and add it to their repertoire of knowledge and skill, they are confronted with a second task: the task of remembering it. Remembering is a challenge because of a natural feature of human memory-forgetting. Forgetting is such an apparent part of human memory that it is often the first thing that people think of when they bring up the topic of memory.

The following section discusses how remembering and forgetting happens in predictable ways that help keep human memories tuned to the demands of everyday life. Memories help people keep fresh precisely those things needed next, and let slip those things that have outlived their usefulness. Understanding the factors that determine what is remembered and what is forgotten helps instructor and learner get the most from memory.

How Usage Affects Memory

The ability to retrieve knowledge or skills from memory is primarily related to two things: (1) how often that knowledge has been used in the past; and (2) how recently the knowledge has been used. These two factors are called frequency and recency of use. Frequency and recency can be present individually or in combination.

Frequency and recency—knowledge that enjoys both frequency and recency is likely to be retrieved easily and quickly. This is knowledge much used in the past that continues to be used in the present. This is the ideal situation for knowledge and skills that need to be used.

Frequency only—knowledge that has been used much in the past but that has not been used recently is vulnerable to being forgotten. This type of knowledge is likely to be retrieved slowly or not at all. To retrieve this knowledge and skill, some recent rehearsal or practice needs to be added in order to refresh the memory.

Recency only—knowledge that has been recently used but has not been used in the past is knowledge that has been recently acquired. This type of knowledge is particularly vulnerable to being forgotten since there is little to distinguish it from “throw away” knowledge, such as an hourly weather broadcast. To remember this knowledge requires a program of regular rehearsal to build up its frequency.

Forgetting

Forgetting, which refers to loss of a memory, typically involves a failure in memory retrieval. The failure may be due to the decay or overwriting of information which has been temporarily stored in STM, but generally forgetting refers to loss of information from LTM. The information is not lost, per se, it is somewhere in the person’s LTM, but he or she is not able to retrieve and remember it.

Why do people forget? Why don’t we remember everything? Do we need to remember everything? Most of the information people are exposed to each day has a short period of usefulness with little need to retain it. For example, why would anyone need to remember the details of an hourly weather broadcast ten years ago?

Thus, forgetting knowledge is not always a bad thing. For example, forgetting old information keeps new information up to date. Many theories on why people forget have been offered to explain the phenomenon, among them retrieval failure, fading, interference, and repression or suppression.

Retrieval Failure

Retrieval failure is simply the inability to retrieve information, that tip-of-the-tongue phenomenon when a person knows the meaning of a word, or the answer to a question, but cannot retrieve it. It is also caused by the fact that sometimes people simply do not encode information well and the information never makes it to LTM or is lost before it can attach itself to the LTM. This is sometimes referred to as failure to store.

Fading

The theory of fading or decay suggests that a person forgets information that is not used for an extended period of time, that it fades away or decays. It had been suggested that humans are physiologically preprogrammed to eventually erase data that no longer appears pertinent.

On the other hand, experimental studies show that a hypnotized person can describe specific details of an event, which normally is beyond recall. Apparently the memory is there, locked in the recesses of the mind. The difficulty is summoning the memory to consciousness or retrieving the link that leads to it.

Interference

Interference theory suggests that people forget something because a certain experience has overshadowed it, or that the learning of similar things has intervened. This theory might explain how the range of experiences after graduation from school causes a person to forget or to lose knowledge. In other words, new events displace many things that had been learned. From experiments, at least two conclusions about interference may be drawn. First, similar material seems to interfere with memory more than dissimilar material; and second, material not well learned suffers most from interference.

Repression or Suppression

Freudian psychology advances the view that some forgetting is caused by repression or suppression. In repression or suppression, a memory is pushed out of reach because the individual does not want to remember the feelings associated with it. Repression is an unconscious form of forgetting while suppression is a conscious form.

Forgetting information does not mean it is gone forever. Sometimes it is still there, just inaccessible.

Retention of Learning

Each of the theories of forgetting implies that when a person forgets something, it is not actually lost. Rather, it is simply unavailable for recall. The instructor's problem is how to make certain that the learner's learning is readily available for recall. The following suggestions can help.

Teach thoroughly and with meaning. Material thoroughly learned is highly resistant to forgetting. This is suggested by experimental studies and it also was pointed out in the sections on skill learning. Meaningful learning builds patterns of relationships in the learner's consciousness, which is one reason to conduct SBT. In contrast, rote learning is superficial and is not easily retained. Meaningful learning goes deep because it involves principles and concepts anchored in the learner's own experiences. The following discussion emphasizes five principles, which are generally accepted as having a direct application to remembering.

Praise Stimulates Remembering

Responses that give a pleasurable return tend to be repeated. Absence of praise or recognition tends to discourage, and any form of negativism in the acceptance of a response tends to make its recall less likely.

Recall Is Promoted by Association

As discussed earlier, each bit of information or action, which is associated with something to be learned, tends to facilitate its later recall by the learner. Unique or disassociated facts tend to be forgotten unless they are of special interest or application.

Favorable Attitudes Aid Retention

People learn and remember only what they wish to know. Without motivation there is little chance for recall. The most effective motivation is based on positive or rewarding objectives.

Learning with All Senses Is Most Effective

Although people generally receive what is learned through the eyes and ears, other senses also contribute to most perceptions. When several senses respond together, a fuller understanding and greater chance of recall is achieved.

Meaningful Repetition Aids Recall

Each repetition gives the learner an opportunity to gain a clearer and more accurate perception of the subject to be learned, but mere repetition does not guarantee retention. Practice provides an opportunity for learning, but does not cause it. Further, some research indicates that three or four repetitions provide the maximum effect, after which the rate of learning and probability of retention fall off rapidly.

Along with these five principles, there is a considerable amount of additional literature on retention of learning during a typical academic lesson. After the first 10–15 minutes, the rate of retention drops significantly until about the last 5–10 minutes when learners wake up again. Learners passively listening to a lecture have roughly a five percent retention rate over a 24-hour period, but individuals actively engaged in the learning process have a much higher retention. This clearly reiterates the point that active learning is superior to just listening.

Mnemonics

A mnemonic uses a pattern of letters, ideas, visual images, or associations to assist in remembering information. It is a memory enhancing strategy that involves teaching learners to link new information to information they already know. Its chief value lies in helping learners recall information that needs to be recalled in a particular order by encoding difficult-to-remember information in a way that makes it easier to remember. Research shows that providing learners with memorization techniques improves their ability to recall information. Mnemonics include but are not limited to acronyms, acrostics, rhymes, or chaining.

Acronyms form a word from the first letters of other words. For example, “AIM” is the acronym for Aeronautical Information Manual.

An acrostic is a poem, word puzzle, or other composition in which the first letter of each line or word is a cue to the idea the learner wishes to remember. For example, Every Good Boy Does Fine is used to remember the order of the G-clef notes in music. An example of a useful aviation acrostic is the memory aid for one of the magnetic compass errors. The letters “ANDS” indicate:

- Accelerate
- North
- Decelerate
- South

Rhymes and melody are another way to remember information. Rhymes such as “In 1492, Columbus sailed the ocean blue.” Most children learn the alphabet using a familiar melody “Twinkle, Twinkle, Little Star.” A well-known mnemonic rhyme for remembering the days of the month is the familiar, “30 days hath September, April, June, and November...”

Chaining is used for ordered or unordered lists and consists of creating a story in which each word or idea that needs to be remembered cues the next idea.

Variations of the encoding process are practically endless. Developing a logical strategy for encoding information is a significant step in the learning process.

Transfer of Learning

Transfer of learning is broadly defined as the ability to apply knowledge or procedures learned in one context to new contexts. Learning occurs more quickly and he or she develops a deeper understanding of the task if he or she brings some knowledge or skills from previous learning. A positive transfer of learning occurs when the individual practices under a variety of conditions, underscoring again the value of SBT.

A distinction is commonly made between near and far transfer. Near transfer consists of transfer from initial learning that is situated in a given setting to ones that are closely related. Far transfer refers both to the ability to use what was learned in one setting to a different one as well as the ability to solve novel problems that share a common structure with the knowledge initially acquired. There is a third way to talk about transfer called generativity. In this context it means learners have the ability on their own to come up with novel solutions.

During a learning experience, previous knowledge usually aids the learner, but sometimes interferes with the current task. Consider the learning of two skills. If the learning of skill A helps to learn skill B, positive transfer occurs. If learning skill A hinders the learning of skill B, negative transfer occurs. For example, the practice of slow flight (skill A) helps Beverly learn short-field landings (skill B). However, practice in making a landing approach in an airplane (skill A) may hinder learning to make an approach in a helicopter (skill B). It should be noted that the learning of skill B might affect the retention or proficiency of skill A, either positively or negatively. While these processes may help substantiate the interference theory of forgetting, they are still concerned with the transfer of learning.

It is clear that some degree of transfer is involved in all learning. This is true because, except for certain inherent responses, all new learning is based upon previous experience. People interpret new things in terms of what they already know.

Many aspects of teaching profit by this type of transfer, perhaps explaining why learners of apparently equal ability have differing success in certain areas. Negative transfer may hinder the learning of some; positive transfer may help others. This points to a need to know the learner's past experience and current knowledge. In lesson and syllabus development, instructors can plan for transfer by organizing course materials and individual lesson materials in a meaningful sequence. Each phase should help the learner understand what is to follow.

The cause of transfer and exactly how it occurs is difficult to determine, but no one disputes the fact that transfer occurs. For the instructor, the significance of transference lies in the fact that the learners can be helped to achieve it. The following suggestions are representative of what educational psychologists believe should be done:

- Plan for transfer as a primary objective. As in all areas of teaching, the chance for success is increased if the instructor deliberately plans to achieve it.
- Ensure that the learners understand that information can be applied to other situations. Prepare them to seek other applications.
- Maintain high-order learning standards. Overlearning may be appropriate. The more thoroughly the learners understand the material, the more likely they are to see its relationship to new situations.
- Avoid unnecessary rote learning, since it does not foster transfer.
- Provide meaningful learning experiences that build confidence in their ability to transfer knowledge. This suggests activities that challenge them to exercise their imagination and ingenuity in applying their knowledge and skills.
- Use instructional material that helps form valid concepts and generalizations. Use materials that make relationships clear.

Habit Formation

The formation of correct habit patterns from the beginning of any learning process is essential to further learning and for correct performance after the completion of training. Remember, primacy is one of the fundamental principles of learning. Therefore, it is the instructor's responsibility to insist on correct techniques and procedures from the outset of training to provide proper habit patterns. It is much easier to foster proper habits from the beginning of training than to correct faulty ones later.

Due to the high level of knowledge and skill required in aviation for both pilots and maintenance technicians, training has traditionally followed a building block concept. This means new learning and habit patterns are based on a solid foundation of experience and/or old learning. Everything from intricate cognitive processes to simple motor skills depends on what the learner already knows and how that knowledge can be applied in the present. As knowledge and skill increase, there is an expanding base upon which to build for the future.

How Understanding Affects Memory

The ability to remember is greatly affected by the level of understanding of what has been learned. Many studies have demonstrated a depth-of-processing effect on memory: the more deeply humans think about what they have learned, the more likely they are able to retrieve that knowledge later. Depth-of-processing is the natural result of the kinds of learning activities described earlier: beginning with memorized information and then elaborating upon it, making associations, constructing explanations, all in pursuit of furthering understanding.

The effects of depth of processing on memory are quite powerful and result from even the simplest attempts to elaborate on what has been learned. One study asked participants to memorize sentences such as "The pilot arrived late." Half of the participants simply memorized the sentences as they were. The other participants were asked to develop an elaboration for the sentence such as "because of the bad weather."

When put to a test, participants who created elaborations were significantly better able to recall the sentences. When memories for sentences had decayed, it seems that remembered words from the elaborations helped people recall them.

Remembering during Training

Remembering what is learned on a day-to-day basis is the first challenge learners need to meet. As learners are presented with new knowledge each day, they should work to maintain that new knowledge plus all the knowledge they learned on previous days. Indeed, remembering during training is a challenge that increases in magnitude each day.

The first threat to newly acquired knowledge is a lack of frequent usage in the past. To address this threat, the learner needs to engage in regular practice of what they have learned. Learners often put off daily studying in favor of "cramming" the night before an evaluation. These learners should be made aware that shorter and regularly spaced study sessions produce memory results that far exceed those obtained from cramming.

A second threat to newly acquired knowledge exists if a learner lacks the degree of understanding that may assist with the recall of that knowledge. Study practices that combine repetition of knowledge along with efforts to increase one's understanding of the knowledge lead to best results. The idea of reading with "study questions" in mind is one that has received much attention by memory researchers.

Experiments have found that not only does answering study questions lead to better memory, but so does the very act of creating study questions. In one experiment in which learners read a text and were then tested on their comprehension, learners who wrote their own study questions and then discarded them unanswered exhibited better recall than learners who simply read the text.

Remembering after Training

Learners should leave the training environment with a sound understanding that a certificate is in no sense a guarantee that they will remember anything that they have learned. It seems that no one is exempt from the process of forgetting. Continued practice of their knowledge and skill is the only means of retaining what they learned, and practice is important after they become certificated pilots and mechanics as it is during their training.

One study of pilots' retention of aeronautical knowledge showed that learners' retention of some topics was superior to that of their own instructors. It seems that the learners' active use and recent rehearsal of these knowledge topics in preparation for knowledge and practical tests outweighed the effects of the more frequent (but less recent) usage on the part of the instructors. This finding nicely demonstrates that an instructor's knowledge is just as vulnerable to forgetting when it has not been recently practiced.

In the same study, the ability of certificated pilots to remember details about regulations was related to the number of months since each pilot's last flight review. This suggests that pilots may take steps to sharpen their knowledge before a flight review and allow it to decay between reviews. Even skills that become automatic during training may not remain automatic after a period of disuse.

Sources of Knowledge

Aviation learners obtain knowledge from a variety of sources while training to be pilots or mechanics. The aviation instructor is the learner's primary source of knowledge, but an instructor also recommends other sources of knowledge. These include books, photographs, videos, diagrams and charts, and other instructional materials. These sources are important for the learner because they allow information to be archived and easily transferred from one person to another. They also allow the reader to self-pace the acquisition of information and permit the reader to pause, think, formulate, and reformulate his or her understanding.

The instructor also encourages the learner to gain experience in the real-world of aviation. These experiences enhance the learner's incidental learning: observation of other pilots or mechanics, thinking about what has been learned, formulation of schemas, and ability to make correlations about what has been learned. Interactive computer-based instruction programs, another excellent source of knowledge, often go hand-in-hand with the flight training syllabus, assuring academics are delivered just-in-time to complement lessons.

Summary of Instructor Actions

To help learners remember what they have learned, the instructor should:

- Discuss the difference between short-term memory and long-term memory.
- Explain the effect of frequent and recent usage of knowledge on remembering and forgetting.
- Explain the effect of depth of understanding on remembering and forgetting.
- Encourage learner use of mnemonic devices while studying.
- Explain the benefits of studying at regularly spaced intervals, and the disadvantages of "cramming."

Chapter Summary

Learning theory has caused instruction to move from basic skills and pure facts to linking new information with prior knowledge, from relying on a single authority to recognizing multiple sources of knowledge, and from novice-like to expert-like problem-solving. While educational theories facilitate learning, no one learning theory is good for all learning situations and all learners. Instruction in aviation should utilize a combination of learning theories.