Presented with two samples to contrast, the student must remember that there is a test called the Student t-test and decide that it is an appropriate test for the data at hand. Then she must retrieve the formula for the test, find and plug in values for the variables in the formula correctly, and solve for the correct result.[1]

This example illustrates that although skill learning and fact learning both involve the acquisition of new information, they differ in the types of information that must be learned and the ways in which the learner uses the information. The first obvious difference between fact learning and skill learning is that a skill has an *execution component* that is quite specific to that skill and the requirements for execution vary considerably from skill to skill. The output for many skills comes in the form of complex motor activity, such as pressing a certain sequence of keys or fitting together the parts of a device. In contrast, the output modes for demonstrating mastery of a fact are general, simple and well-learned: the learner vocalizes or writes the fact that is retrieved from memory or signals whether the retrieved representation meets some criterion (e.g. recognition or paraphrase match).

One reason for the variation is that skills are often built up out of component skills, which are called on in the manner of 'subroutines'. For example, performing a t-test involves at least two component skills: finding the mean and the standard error of a sample. A different procedure might involve finding a different mean, but using some of the same values to determine the error term. The relationship between facts in a domain seems qualitatively different from the relationship between subroutines embedded in a procedure. While it is common to 'unpack' a concept by retrieving related concepts, the process is seldom as routine and unvarying as performing a fixed subroutine.

Another difference between skill learning and fact learning is that the context in which a fact is retrieved can facilitate access to the learned information. A learner demonstrates fact learning by retrieving a fact in response to a query. The query not only provides a retrieval cue, but it also provides an appropriate occasion for retrieving that particular fact. In other words, a person can be considered to have mastered a fact if he or she can recall it when specifically queried. But recall of procedures when queried is not sufficient for mastery of a skill. Knowing how to perform a skill requires that the learner understand and appreciate the contexts in which a particular procedure is appropriate. In the case given above, deciding to use the t-test rather than some other test depends on knowing something about the function of the t-test and something about the data to be analyzed. Granted, it is just as important to know when to use a fact as when to use a procedure.

[1] Remembering that the name of the test is 't-test' is not critical in this case, but in other skill tasks (such as using a computer or constructing a proof), remembering the name of a procedure can be quite important.

The difference is, however, that learning a skill means knowing when to use the acquired procedures but learning a fact does not. A test of skill learning should measure the learner's ability to choose procedures appropriately.

In addition to differences in what must be learned, there are also differences in how we view 'mastery' of a fact versus a skill. Although facts can vary in learnability and strength, we usually do not judge 'how well' a fact is recalled when it is recalled. In contrast, procedures not only vary in ease of learning, but most require practice for any degree of competence to be attained. That is why in skill domains, we classify practitioners as experts, novices or intermediates. We do not say that someone is 'skilled' in a particular domain until she can execute the procedures rapidly and rather effortlessly. A person who is slow to execute basic procedures or who rehearses the requisite steps 'declaratively' is usually judged to be a novice.

Because skill learning involves different output requirements and different standards for proficiency, we need new, more sensitive measures in order to study skill learning. But, more importantly, we need to consider closely the cognitive mechanisms of skill learning and how they interact with those of fact learning. If skill learning draws heavily on declarative knowledge, then we might expect factors that affect encoding, retention and retrieval from declarative memory to be important for skill learning. Conversely, if skill learning and fact learning involve largely independent processes, then we might not expect conditions that facilitate fact learning to have much benefit for skill learning.

One model of cognition that carefully considers where declarative knowledge interacts with procedural knowledge is Anderson's (1983) ACT* model. Anderson follows Fitts (1964) is positing that learners initially acquire a skill in declarative form, usually from oral or written instructions. Procedural knowledge of the skill, in the form of a production system, arises only after hands-on practice. At first, in order to approximate the required skill behavior, the learner uses a set of general-purpose productions to retrieve segments of the declarative representation of the instructions, and translate them into a series of actions. With additional practice, the learner gradually constructs a set of skill-specific productions that directly incorporate the relevant declarative knowledge, eliminating the extra step of retrieving this information from declarative memory. As the productions are compiled and tuned, skill performance improves dramatically; performance becomes much more efficient and requires much less conscious attention.

In this model, declarative knowledge becomes increasingly superfluous to skill performance as learners gain expertise, but the declarative representation is critical to the initial stages of skill learning. We might expect, then, that factors influencing the formation of the declarative representation would strongly influence initial skill performance. In particular, the form of the verbal instructions on which the declarative representation is based is clearly