Knowledge, Knowing and the Scientific Method

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Introduction

The study of the theory relating to some field is made to help secure and expand knowledge about the practice of that field. We seek a disciplined approach to finding reliable ways to improve our understanding of the practice and make predictions about what will work. An important goal is to learn to critically examine what we know about the field, and to develop methods of genuinely expanding our knowledge. This essay introduces some concepts about the nature of knowing, knowledge acquisition, the learning of faulty knowledge, and a very general description of the scientific method. It is meant to provide food for thought and set the stage for later discussions about multimedia practice.

The Nature of Knowing

One characteristic of human beings that apparently is unique is the transmission of knowledge from one generation to the next. First through oral tradition, and later by various types of recording (clay tablets, writing, audio and video tape) humans accumulate knowledge. As a result, any one of us "knows" much more than personal direct experience could teach us in many lifetimes.

We "know" that there are seven continents on planet Earth, even if we have never traveled more than a hundred miles from home.

We "know" that George Washington was the first President of the United States.

We may "know" that the crust of the Earth is composed of many discrete pieces that float on the liquid mantel below, and that the collisions and subductions of these plates results in mountain-building and volcanic activity.

We may "know" that certain diseases are caused by the action of bacteria on parts of the body, and we "know" that the immune system can be primed to fight them by the injection of proteins from the dead strains of bacteria.

Consider all things you *know*. How did you acquire the knowledge? How does anyone know what they know? The study of how we come to know things is epistemology. Understanding the various ways that we can come to know something is useful in trying to develop a meaningful set of principles to explain and predict phenomena in the surrounding world, because we want to base our principles on sound knowledge. Critically examining the source of knowledge can help us weed out incomplete or faulty ideas that might mislead us.

For instance, many people "know" that mammals are the only creatures that give live birth—perhaps because they have never heard of guppies doing so. Someone might "know" that there is no gravity in the space between the earth and the moon. We might "know" that as a young boy, George Washington chopped down a cherry tree, or threw a silver dollar across the Potomac River. The amount of political strife in the world that results from various factions "knowing" some thing or other is a clear indication of the damage that may result from knowledge that finds its way too easily into one's accepted understanding of truth.

Where Does Knowledge Come From?

The most obvious way to acquire knowledge is through direct personal experience. You may suppose that this describes most of your knowledge, but consider that what you read in a book, what you see on television, and what you hear in a lecture are all at best second-hand. Direct personal experience is well illustrated by the example of the child who learns that the stove is too hot to touch by actually touching it and getting burned. Direct experience can be a wonderful (if somewhat painful) teacher. However, if our ability to acquire knowledge were limited to this mode, civilization and culture would, for better or worse, be stalled at some point in the remote past—a million or so years, perhaps.

The advent of spoken, and then drawn and written communication made it possible for our forbears to share what they had learned with later generations. Owing to this passing-on of knowledge, each generation may build on previous knowledge and benefit from the direct experiences of countless previous learners. All we read, hear in lectures (or radio or gossip), all we see on television and billboards, is second-hand knowledge. Some piece of knowledge may be repeated frequently through several channels, and perhaps we may eventually find it difficult to distinguish this knowledge from that gained by direct experience. We also learn to accept knowledge presented to us by authorities (who rates "authority" certainly varies from one individual to another). Again, once we "know" something long enough, we may not concern ourselves with the source.

Acquisition of Erroneous Knowledge

The fact that we "know" something does not mean that thing is necessarily true, regardless of the source. Based on direct personal experience, one may make incorrect deductions about cause and effect. An observer may not see all the relevant details of some situation and draw erroneous conclusions. For instance, during the dark ages, it was widely believed that rats and other vermin spontaneously generated from the ever-present refuse that lay around in streets and alleys. The observed evidence supported this belief—areas free of refuse were free of rats, and the more trash an area had, the greater the rat population.

In addition to originating with faulty empiricism (as in the case in the belief of spontaneous generation of rats from garbage), faulty knowledge may come from acceptance of an authority which is incorrect (or malicious). It is also possible that one acquires an incomplete understanding of a situation that subsequently results in one drawing invalid conclusions (perhaps the reason someone might make the incorrect declaration that "mammals are the only animals that give live birth" or that "negative numbers have no square roots.") Of course, once erroneous knowledge has sufficient weight of authority behind it, it is likely to become entrenched.

In general, the quest for knowledge about something may be confounded by the lack of adequate tools (without powerful microscopes, microorganisms remain undetected), or social convention (for thousands of years, the accepted model of the solar system placed the Earth at the center). There is a tendency to accept the current state of knowledge in some field as nearly complete, or at least as incomplete but correct. However, there is always the possibility that some new refinement in instrumentation will reveal flaws in the accepted "Truth." The quaint notion of spontaneous generation was sincerely believed at the time. Are there things that we sincerely believe now that

may some day seem as absurd?

Acquiring "Valid" Knowledge

In an organized discipline that deals with the natural, physical world (including the physical characteristics of humans, machines, and observable nature, and as opposed to the metaphysical world, which includes unmeasurable human attributes such as love and spirituality), we can devise methods to attempt predicting relationships and then test the predictions. The general approach is called the scientific method. The process involves first developing some set of principles to explain what has been observed (this would be "theory"). A theory may begin as a fairly rough collection of related ideas, and through the work of several people grow more extensive and refined. Growth and refinement result from experiments that test the predictive capacity of the principles.

An experiment is a controlled test of a specific prediction based on theory. The prediction, or hypothesis, is stated as precisely as possible. The test is designed to eliminate as many irrelevant factors as possible, and includes a group which receives the treatment and another that serves as the basis of comparison. The second group (control) experiences the same thing as the treatment group except for factors pertaining to the prediction. (Note that the groups might be collections of potted plants, human volunteers, or batches vials of chemical solutions). A measurement is made after the treatment, and statistical analysis will indicate whether there is a discernible difference between the outcomes. If there is a significant difference, the experiment is said to support the hypothesis. If repetitions of the experiment yield the same result, confidence in the support increases—may indeed become accepted as "fact." But strictly speaking, the hypothesis is never proven, only supported.

There are some areas in experimentation that require careful attention. First, there is always the possibility of some undetected but significant factor which has not been controlled. If this is the case, the uncontrolled factor may be the real cause of difference. There is also the danger of using the wrong measurement. Or perhaps the outcome that should be measured is not even recognized. None of these perils undermines the value of experimentation as a way to further knowledge. However, when designing an experiment we must keep them in mind, and when evaluating existing work we must remember to examine the methods of others closely. Accepting conclusions resulting from poorly-designed experiments is yet another way to acquire erroneous knowledge.

Conclusion

We are preparing to examine theory from several fields that may help us improve our understanding of multimedia design and development. There are already many collections of guidelines and rules-of-thumb in print and on the web for the would-be developer of multimedia titles. Do these guidelines really have solid support? How can we put them to the test, or how have they been tested? Are there more questions we should ask, and how should we proceed in finding the answers? To avoid losing our way as we address these issues we have to keep in mind the nature of knowledge and learning.