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Theoretical Foundations

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CONTENTS

ABSTRACT

This chapter addresses the theoretical foundations for research in educational communications and technology. Four relevant areas are explored: (1) the psychology of learning, (2) communications theory, (3) human–computer interaction, and (4) instructional design and development. Past work in these four areas can be viewed as providing a theoretical foundation for further research and development in educational communications and technology.

KEYWORDS

Educational communications: Forms, means, and methods of expressing and sharing ideas, information, and knowledge to support learning and instruction.

Educational technology: The disciplined application of scientific principles and theoretical knowledge to support and enhance human learning and performance.

Theoretical foundation: A related set of rules and principles that can be brought to bear as a basis for making predictions and providing explanations for a variety of phenomena.

INTRODUCTION

> "May you have a strong foundation when the winds of changes shift." (from Bob Dylan's "Forever Young")

A fundamental aspect of educational communications and technology is change. Television was a new communications technology that influenced (for better or

worse) learning and instruction 50 years ago. Since then, there have been many other new technologies and innovations in educational communications; however, the general problems for educational researchers have remained relatively constant—for example, how to make effective use of a specific technology in a particular educational context. In conducting research for such a purpose, one can proceed on the basis of prior work. What, then, is the nature of theoretical foundations in educational communications and technology?

The Approach

The quick answer is that theoretical foundations are the basis for conducting research in an area. In this chapter, rather than review specific research foundations and cite appropriate sources along the way, I describe the general features of the educational communications and technology research landscape, citing only a very few sources in the main body of this chapter. I have included an extended bibliography at the end of the chapter to help readers extend their investigations in directions that seem useful and appropriate to them (an asterisk in the extended bibliography indicates a critical reference).

There are two reasons for selecting this approach: (1) *the lay of the land*—the general things relevant to most educational technology research are worth discussing as part of our intellectual heritage and identity, and (2) *my lack of expertise*—I do not regard myself as an expert in most of the areas to be mentioned, so the best I can do is to point to things that I believe are relevant. I certainly do not mean to imply that the framework presented here or the items listed in the bibliography are exhaustive or even the most salient aspects of educational technology research. They are simply the things I have stumbled across in my wandering around this intriguing landscape in the last 20 years.

Nature of Research and Theory

The basic question that research aims to answer is why things happen the way they do. Developing an answer to such a question often involves a general rule or principle that has explanatory power or that will be predictive, as we often ask about future events—what will happen if we manipulate or change one or more things in the situation? A related set of rules and principles that has been shown to be reliable in many situations might be regarded as a theory.

Of course, there are different kinds of research questions and a variety of research objects. Appropriate methods depend on the nature of the questions and the objects investigated. Example question types for educational technology researchers include: (1) What will help these students learn this material? (2) Why do those students have difficulty in learning that material? (3) When will this technology and that form of communication be effective with those learners? (4) How can we explain the effects of that change in the instruction? Other types of questions can be framed, as well.

When specific questions are put forth in concrete contexts, one can identify appropriate methods of investigation. Oftentimes in exploratory research involving a new form of communications or a new technology, qualitative methods (e.g., action research, case studies, ethnographic research) are useful in gaining an understanding of and interpreting relevant aspects and factors that seem to influence learning and performance. On the other hand, when developing a general explanation for which factors systematically result in particular outcomes, one might use quantitative methods (e.g., controlled studies with randomized samples, quasi-experimental studies). In some cases, a study might involve both qualitative and quantitative methods depending on the questions being investigated and the research objects involved.

What confounds this already complex area of research and theory is that educational technologists are generally trying to find means to improve learning and performance. When a general instructional approach is devised, initial evidence of its efficacy must be developed. This may involve a formative evaluation that is aimed at making subsequent modifications to improve outcomes. Moreover, in the area of learning and instruction, there are many differences that make it difficult to develop general explanations and predictive theories. What works with one kind of learning task and a particular group of learners may not work with others. The circumstances in which learning occurs may also affect outcomes.

It is a wonder that instructional science has made such progress in the last 50 years given the nature of these obstacles. Some researchers are inclined to abandon the traditional scientific approach altogether, but doing so might be a hasty and unwarranted decision. A more modest approach is to use traditional research methods and make adaptations and modifications as they seem appropriate for particular research circumstances. The starting point of a research inquiry, as suggested earlier, is the admission that one lacks a good explanation for why things happen the way they do. This point of departure across the research landscape involves both *humility* (one begins an inquiry not knowing the outcome) and *openness* (one journeys

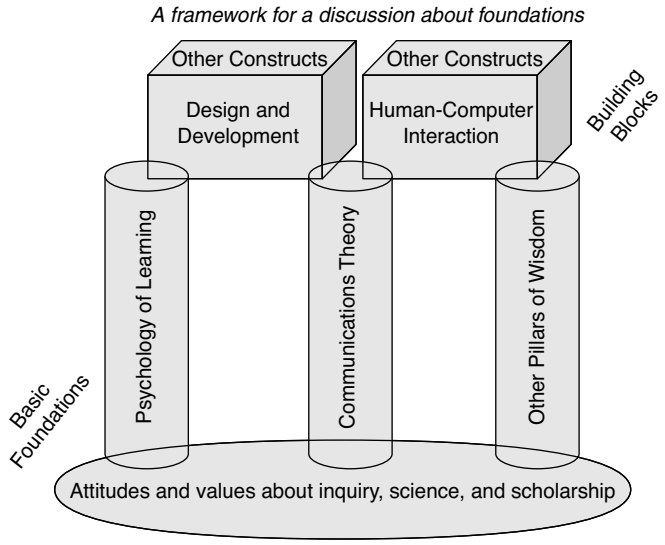

Figure 2.1 A framework for discussing theoretical foundations.

forth open to a variety of outcomes). These two aspects of traditional research and theory—humility and openness—ought to be retained as the core of our theoretical foundations.

Four Foundation Areas

The notion of foundations in a discipline is not new. Having foundations implies having a history. Moreover, foundations imply that there is a solid basis for further work—research and development, in this case. In other words, foundations look both to the past and to the future. In looking to the past, it seems to me that psychology is obviously a critical foundation area—especially the psychology of learning. Human behavior and the development of knowledge and skills are perhaps the bedrock on which educational communications and technology rest. This idea is confirmed by the many graduate curricula in educational technology and instructional systems that include a core course requirement in the psychology of learning (or closely related subject such as the principles of learning). One section of this chapter briefly introduces this foundation area.

The nature of communications and its many forms and variations also seems critical to educational technology. Relevant theories exist to guide both the representation of information and the transmission of information from one place, person, or system to another place, person, or system.

Thus far, I have identified what I regard as two basic foundation areas: what people do (psychology) and what people say (communications). The other two foundation areas to be discussed below are more specific and applied in that they address the ways and means of facilitating what people do and say, especially with regard to their interactions with others (e.g., teachers and students) and with learning materials and instructional systems. One can easily imagine basic values and scientific attitudes in addition to the two cited here—humility and openness (see Figure 2.1). One can also identify other basic foundations and building blocks to support and motivate research in educational communications and technology. The framework presented here (see Figure 2.1) is intended only for purposes of discussion and as an arbitrary point of departure.

In each of these four areas, I identify relevant past research and developments and suggest how these might influence future research and development in educational communications and technology.

PSYCHOLOGY OF LEARNING

In *How We Think*, Dewey (1910) argued that we need to understand the nature of thought to be able to devise appropriate means and methods to train thought. Along the way, Dewey distinguished abstract from concrete thinking and indicated that many training regimens proceeded from the concrete to the abstract. Piaget (1929) identified a parallel progress in the development of reasoning in children. Dewey cited implications for his theory of thought for instructional planning—namely, he argued that effective training involves a balance of many things, including especially information, observation, imagination, reflection, playfulness, and seriousness.

Bruner (1966) made explicit the close relationship between intellectual development as investigated by Piaget (1929) and the practical task of devising support for learning of the kind suggested by Dewey (1910). Since that time, other researchers have devised instructional design frameworks based on new psychological research (see, for example, Merrill and Twitchell, 1993; Reigeluth, 1983, 1999; van Merriënboer, 1997). Meanwhile, the psychology of learning has undergone basic changes, evolving from behaviorism (see, for example, Skinner, 1938) to cognitivism (e.g., Anderson, 1983) to constructivism (e.g., Ford, 1987). Associated with these changes have been changes in how researchers and developers think about instruction (e.g., Driscoll, 2000; Lesgold et al., 1978; Reigeluth, 1983, 1999; Spector and Anderson, 2000).

What seems clear is that there is much more to understand about human psychology and learning. As a consequence, models of instruction are likely to continue to evolve based on our understanding of human behavior, cognition, and emotion. New areas of exploration in psychology that are likely to impact instructional design research include the linkages between neural mechanisms and problem solving as well as the structure of memory and its role in both learning and unlearning.

COMMUNICATIONS THEORY

The second basic foundation to be discussed here is communications theory. The reason for this is that nearly all learning involves language (Vygotsky, 1962, 1978). The relationship of language, thinking, and learning appears in many philosophical analyses; see, for example, Dewey's (1910) *How We Think* and Wittgenstein's (1953) *Philosophical Investigations*. The notion of the central role of language games in thinking and problem solving was elaborated by Wittgenstein (1953). A language game is a rule-governed means of communication adopted by an identifiable community. In the case of learning and instruction, one might regard the professional communities of practice and the language games they have adopted as fundamental units of analysis.

One can find connections between language and learning elaborated in the ancient works of Plato as well as in modern philosophy (Klein et al., 2004; Spector, 1994). In short, language is fundamental to thinking and learning. The many techniques and tools for the expression and sharing of language—communications—are then fundamental aspects of thinking and learning. Moreover, methods of communications are likely to influence learning outcomes and impact the design, deployment, and evaluation of instructional systems and performance environments.

The notion of language games associated with Wittgenstein (1953) places particular emphasis on the use of language. The underlying notion is that it is use and context that give meaning to words and statements, which, without a context and accepted or expected use, are basically lifeless. Although use and context are certainly fundamental to meaning, communications theorists have examined much more with regard to the fundamental aspects of language. For example, Charles Sanders Peirce, Ferdinand de Saussure, Claude Shannon, and others developed and elaborated theories of signs and the rules that govern their use in various contexts (Hardwick, 1977; Saussure, 1959; Shannon, 1948). Saussure (1959) made a clear distinction between the sign and that which is signified. Peirce added a third category—the notion of an icon—and argued that the sign by itself was devoid of meaning. This argument was based on a pragmatic view of language and introduced the notion of language in use that permeates Wittgenstein's *Investigations*. Shannon extended these concepts to include the computer as a user of signs; he created a mathematical treatment of symbol systems that has been widely influential in the computer and information science communities.

As with the other pillars of educational communications and technology mentioned in this chapter, many more things could be cited as fundamental to inquiry and scholarship. Before turning to two applied foundation areas, it is worth mentioning one additional aspect of communications theory that is particularly pertinent to the world of digital media—namely, the notion of visualization as a form of communicating. Tufte (1977) argues that graphics are a form of expression—a language—that can be used more or less effectively in accordance with how well certain rules and guidelines governing their use are followed. Those who are interested in designing effective graphics are well advised to look at Tufte's (1977) writings, which might be considered one of many bridges between the basic foundation area of communications theory and the more applied foundation area of human–computer interaction.

HUMAN–COMPUTER INTERACTION

How one person represents something to another person and the particular form of expression used to convey that representation influence what is likely to be

understood. That is why communications theory is a fundamental consideration in learning and why so much emphasis is placed on the design of instructional messages. Given the widespread use of computers to support learning and the growing use of handheld devices, it seems quite natural to treat the exchange of information between humans and the computers with which they interact as a distinct area. There are certainly psychological aspects to human–computer interaction, as well as communications issues. As a consequence, in this simple framework, human–computer interaction is considered an applied foundation area of educational communications and technology research.

Many aspects of human–computer interaction have been investigated. They include basic human factor issues such as the colors and fonts that are easily discernible on a computer monitor and the various types of control devices and how they can be designed to facilitate human use. Other human use issues include when and how systems might support multiple learners who might be working or learning in different places and at different times. The types of computer-generated messages that are likely to be supportive of learning and performance have been studied in many different contexts and comprise an important area of human–computer interaction research.

Just as different disciplines have specific research methods that are considered appropriate for particular problems, these foundation areas have preferred or commonly used research methods. One of the widely used methods in human–computer interaction studies involves activity theory (Leont'ev, 1975; Nardi, 1996). Activity theory is a framework for studying humans and their use of artifacts. Emphasis is placed on an object's purpose and how it is used by an individual often working with others to achieve a particular goal. Activity theory emphasizes purposeful social interactions and might well be considered a research extension of the notion of a language game.

Perhaps the most well known instructional theory that involves human–computer interaction is Merrill's (1980) component display theory (CDT). An interesting aspect of CDT is that it introduced the issue of learner control and provided guidelines for when control should pass from the instructional computing system to the learner and what should be included in that control. CDT also provided an early version of what was reasonable to display on the computer screen given the current state of a learner's progress through a set of learning materials. These concepts would of course evolve and have given rise to many subsequent studies and instructional design frameworks, which are discussed next.

INSTRUCTIONAL DESIGN AND DEVELOPMENT

The final foundation area to be briefly discussed involves what might be regarded as the core area of professional practice in educational communications and technology—namely, instructional design and development. This is a rich area of empirical research. Given the dynamic nature of learning and instruction and the introduction of new technologies and forms of communications, it is unlikely that this research area will ever be exhausted. In closing out this discussion of theoretical foundations, a model to guide investigations of instructional design and development issues is presented.

Instructional design and development are human activities. The general purpose of these activities is to facilitate and support human learning and performance. To achieve desired outcomes, instructional designers have developed instructional design models and principles, based in large part on the psychology of learning and what is known about effective communications (Gustafson and Branch, 2002). These models suggest that different instructional methods and strategies are likely to be effective in different circumstances (Gagné, 1985; Merrill and Twitchell, 1993). Instructional design principles have been developed that link back specifically to the psychology of learning and human perception (Gagné et al., 1992). Specific instructional design models have been developed to fit particular types of learning outcomes.

One of the more robust and well elaborated of these models in the four-component instructional design (4C/ID) model developed by van Merriënboer (1997). In 4C/ID there is a fundamental distinction between recurrent and nonrecurrent tasks—that is to say, those tasks whose performance remains relatively constant in spite of variations or changes in the surrounding conditions (recurrent tasks) and those requiring significant changes in performance due to changes in the surrounding conditions (nonrecurrent tasks). Instructional support for the former might include part-task training aiming for automaticity of task performance; instructional support for the latter might include whole-task demonstrations and practice in a variety of circumstances guided by heuristics and a mentor or coach.

A theoretical framework that accommodates all of these different models and associated research can be found in Reigeluth (1983). Reigeluth argues that a basic difference between psychological research on learning and instructional design research is that the former is primarily descriptive (these learners under

those conditions achieved particular outcomes), whereas the latter is primarily prescriptive (to achieve a desired outcome given certain conditions, one ought to use that instructional strategy). This instructional design research framework can be applied at the lesson level or for an entire course or program.

Some researchers have challenged the descriptive–prescriptive distinction as being a naïvely objectivist view that overlooks the fact that values are involved in descriptive research just as they are obviously involved in prescriptive research. While I happen to acknowledge the fundamental nature of attitudes and values for all human activity (recall Figure 2.1), I believe that Reigeluth's framework remains a valid guide for ongoing research in our discipline. Indeed, I believe instructional design research and theory would become a marginalized craft without much influence or impact on education without such a sound theoretical foundation.

CONCLUSION

It is my hope that a basis for ongoing dialog about theoretical foundations has been established in this chapter. I realize that I have traversed much landscape but not provided very much detail. I acknowledge having ignored much that is relevant. These errors of commission and omission could form the basis for discussion and leave the author of the Theoretical Foundations chapter in the next edition of this *Handbook* much more about which to write.

In closing I would like to return briefly to the two basic values that provided a point of departure: humility and openness. It is clear to me that a great many have contributed to our knowledge about educational communications and technology. I have chosen to include an extended bibliography rather than a simple list of references so as to emphasize that fact. Indeed, we stand on the shoulders of giants. The problem is deciding whose shoulders to use for a meaningful boost up and look over the landscape. Part of developing a sense of humility is realizing the significance of what so many who have preceded us have accomplished.

A second pathway to humility is realizing how limited our own understanding is on any particular issue of any complexity at all. I have adopted the following mantra for this purpose—surely it would be a remarkable coincidence if the limits of my imagination happened to coincide with the limits of reality. Openness follows naturally from a sense of humility and the realization that others often have excellent ideas.

As educational researchers, we might wonder what will come from what we have done, are now doing, and are likely to do in the future. We conduct studies, we write articles and books, we pile up accomplishments, and yet there is always more to be done, new territory to be explored, alternative explanations to investigate, new methods to try, and so on. I am reminded of a sonnet written by Percy Bysshe Shelly (1818) with which I close:

Ozymandias

I met a traveler from an antique land
Who said: Two vast and trunkless legs of stone
Stand in the desert … Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them, and the heart that fed;
And on the pedestal these words appear:
"My name is Ozymandias, king of kings:
Look on my works, ye Mighty, and despair!"
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away.

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* Indicates a core reference.