Technology or Craft: What are we doing?[1]

Richard Clark
University of Southern California

Fred Estes
Hewlett Packard Company

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Tech - nol - o - gy (tĕk-nŏl'-ĕ-jē) *n. pl.* -gies
The application of science, especially to industrial or commercial objectives. The entire body of methods and materials used to achieve such objectives

Craft (krăft, kräft) n. pl. crafts.
Skill or ability in something... Proficiency; expertness... Indicates work, art or practice of, for example, woodcraft, stagecraft.[2]

The origin of this essay was a request from the Editor, Larry Lipsitz, for a reflective article on where we currently stand and where we are going in Educational Technology. His concern is based, in part, on the perception of a number of people who have monitored educational technology scholarship over the years (for example, Clark, 1983, 1988a, b, 1994; Cuban, 1986; Ellul, 1990; Heinich, 1984; Kaufman, 1998; Kearsley, 1998) that well-designed research and evaluation does not provide evidence for expected educational technology results. In addition, many scholars since the turn of the century have suggested that our field is founded on a shared misunderstanding of technology and thus cannot hope to find the best solutions for many of the problems it is addressing.

Our involvement in this issue is both personal and professional. For a number of years, both of us have balanced teaching, research and practice in educational technology. We both experience more people today who are enthusiastic about educational technology solutions that have face validity and seem intuitively correct but lack supporting evidence. We also notice, along with Greg Kearsley (1998) and others, that most people in our field continue to define technology as "machines and media". Even more distressing is our impression that good evidence more often suggests a lack of effectiveness for many uses of educational technology as

[1] This article is the first of a multi-part discussion of technology in education. Other articles in this series will discuss how technology develops, how we can foster its development and how to change our current emphasis so that it reflects a valid view of technology in education. Comments or questions about this article can be directed to Richard Clark clark@usc.edu.

[2] Morris, W. (Ed.) (1973) *The American Heritage Dictionary of the English Language*. Boston: Houghton Mifflin Company.

it is currently defined and practiced, despite the enthusiasm we experience from students, colleagues, the general public and industry professionals. Recent examples of such enthusiasms are directed at distance education, virtual reality and multi media. We realize that pressures from employers limit the amount of time professionals have available to master a complex and sometimes conflicting research literature even more today than even a decade ago. We are very aware of the enthusiastic testimonials for these “new technologies” from people who are effective in communicating and persuading others to use them. And we are very alarmed by the increasing number of our students and colleagues who not only ignore the lack of research evidence to support technology enthusiasm, too many people simply do not trust research. We get the impression that much of this distrust comes from a lack of support one finds in the research for people’s intuition about the benefits of educational technology. Their reasoning seems to suggest that if research does not find evidence for something that seems so powerful, then research as an inquiry strategy must be flawed. Since researchers often seem to disagree, too many of our colleagues get the impression that the social and educational sciences are “opinion” and that all opinions are equally valid. This phenomenon is not limited to educational technology but can be found in all social and organizational issues. One consequence we notice is that more people advocate a greater proportion of failed or limited educational and organizational strategies which do not measure up when subjected to robust evaluation (see for example the discussion of organizational change and empowerment motivation strategies by Golembiewski and Sun; 1990; Neuman, Edwards and Raju, 1989; and reviews of comparative media studies by Clark, 1983; 1994). As part of this trend, we have also noticed the tendency of university educational technology programs to become increasingly insular, reduce the emphasis on the technology of research and avoid the responsibility to correct student’s intuitive beliefs about technological solutions (Clark, 1978; 1988a). The result is a gradual eroding and splintering of our field.

The Purpose Of This Article:

In this article, and those that follow in this series, we will make the argument that the reason this field is languishing at a time when there is great international interest in educational technology, is that we have confused craft and technology and we have too narrowly focused educational technology on media and distance education as we attempt to solve educational problems.

We will contend that what too many educational technologists have been describing in the pages of this journal and others is not technology but craft. While craft is valuable and, in the absence of technology, the only alternative solution to problems, confusing the two approaches is deadly. Even worse, our craft has too often been targeted on the wrong problems and solutions. We will also suggest that the medieval origin of craft encourages too many of us to advocate solutions and then go in search of educational problems the solution may help. We will suggest that in order to connect with root sciences, technology development must begin with a clear understanding and validation of problems to be solved and consider solutions only after a careful consideration of the problem. In this essay, we will describe the positive and negative qualities of both craft and technology and give examples of the consequences of emphasizing one over the other. We will urge a greater blending of the two approaches. In forthcoming essay’s we will describe, in some detail, how a technology of education develops; how we can foster its development in environments where people have many demands on their time, and how we might change this field so that it is oriented towards the appropriate blending of technology and craft to solve educational problems.

Educational Technology and Educational Craft

As most dictionary definitions indicate, technology is the application of scientific knowledge to solving practical problems (Heinich, 1984; Galbraith, 1967). The chain of events that lead from science to technology to educational practice is what John Dewey (1900) called a "linking science... between theory and practical work" (p. 110). Our technology of education has produced diverse offspring such as improved tests for selection, aptitude and achievement measurement; effective organizational strategies such as change tactics; new cognitive theories of motivation applied to instruction; modular scheduling and approaches to school consolidation; job and task analysis; modular building designs; instructional design models and teaching methods. All of these issues and problems are also addressed by craft. In craft we see emphases in areas such as learning styles such as the Meyers-Briggs instrument, empowerment motivation strategies, and competency models. So we cannot distinguish between the two approaches on the basis of the problem they attempt to solve. Two of the key defining elements of a technology are the connection between the root science and the practical problem being solved by the technology and the generalizability of the solution once it is developed. One of our concerns is that the problems we have been attempting to solve are not always those their root science was addressing and usually are not problems that can be solved by media. The best example of this problem is our obsession with media in all of its current and electronic forms (e.g. Clark, 1983; 1994). The development of the connection between science and effective technology is accomplished with the use of "linking sciences and technologies" for applying scientific theory and models to the solving of practical problems (Dewey, 1900; Bruner, 1964; Glaser, 1987; Simon, 1981: Clark, 1988a). Further, we suggest that too many of us have unintentionally been engaged in educational craft which is experience based, marginally effective where it was developed and not reliably transferrable to a new situation. We will also argue that craft approaches allow us to easily confuse the connection between problem and solution.

What is Educational Craft and what are its benefits? Much of human knowledge is based on craft. The person developing a craft solution to a problem draws on fortunate accidents, personal experience, insight and the expertise of others to fashion a solution and revise it through trial and error. Craft is then passed on through a system of expert-based instruction and practice-based apprenticeships. In many instances, evaluation studies indicate that craft solutions are successful in the setting where they are designed. Craft is also quite easy to learn and its use seldom requires much training or prior experience. Craft approaches produce a body of knowledge and expertise that is sometimes personal but more often passed on through guilds, unions, professional associations or other collections of experts and student novices. Teaching and training are largely craft-based activities despite the role of colleges and universities in the training of school teachers and business trainers. Many instructional design and development strategies are largely craft based. Medicine was a craft when it was developed and has been making a gradual transition to technology over the past century. Building trades such as carpentry, stone masonry and construction planning began as craft and gradually evolved into engineering. Presently, engineering is largely a technology although it draws on its craft origins when the root science of a problem is absent or inadequate. The reasons for the evolution from craft to technology in medicine and engineering are pragmatic. Technology works better when success is evaluated (Dewey, 1900). Thus, the development of fields of knowledge tend to follow a pattern where early insights are gained through craft and then, as the field matures, the limitations of craft motivate an emphasis on science and its related technologies. What has apparently happened in educational technology is that we continue to develop craft solutions when science and technology are available, but we are calling what we do “technology”.

What Is Wrong With Craft solutions? If craft solutions often work, even if their success is limited to a very specific setting, why discourage their use? There are at least three serious faults in a craft solution – they are indeterminate, non transferrable and unconnected to a systematic knowledge base.

One of the most important flaws of a craft is that its solutions have indeterminate causes. We do not know why they work. Craft solutions are seldom linked to a larger body of knowledge where established scientific principle and causes are explained. While people who develop the craft have explanations for why they work, closer scrutiny indicates that these explanations are seldom correct (Heinich, 1984; Gage, 1985; Shulman, 1986; Clark, 1988b). This means that we are in doubt about which part of the craft solution is the “active ingredient” that leads to measured outcomes. Thus, most craft solutions contain elements that are either inefficient and/or counter productive (in that they may cause unintended side effects). However, by itself, this fault is not always destructive only inefficient. So we do not know why they work, in fact some of them do work and do solve important problems. Do we need to know why they work? Must we be able to identify their active ingredients and relate them to a larger body of research and theory? The answer to these questions is “No, we do not need to know why they work, unless we want to transfer the solution beyond its initial context”. The key utility of any insight is in its generalizability. If knowledge was context specific, we would have to invent a new solution each time we encountered the same problem in a new context, or with different people or tasks. Clark (1988a) has argued that we do not often learn about the lack of generalizability of craft solutions because they often carry the strong endorsement of their original developers or from people in the original application context. Since these endorsements are based on the actual experiences of real people in real settings, they are trusted more than the cautions and concerns of research and evaluation specialists who are perceived as less experienced in the real world.

According to historian Barbara Ward (1962) the difference between craft and technology is as profound as the difference between primitive and advanced societies. In her essay’s on the development of modern civilizations, Ward gives technology the credit for the efficiencies that permit the development of advanced societies. She provides historical evidence to support her view that “... there is virtually no science in tribal society. There is a good deal of practical experience, skilled work and early technique. It seems possible, for instance, that primitive farming developed as a result of close observation of nature’s cycle...but the idea of controlling things by grasping the inner law of their construction is absent” (p. 47). Understanding the “inner law” is the essence of science and technology. Yet, she argues, members of modern technological societies do not necessarily understand science and technology nor recognize their impact on our social and economic achievement. Many historians have described the tendency in modern civilizations to “scientize” craft using scientific language and measurement technologies (Ellul, 1990).

Thus, the second problem with a craft solution is that they are situated. Because they are unconnected to a body of systematically gathered scientific knowledge, they are seldom transferable to new settings and/or people. Craft developments are one of the primary reasons why the literature on the transfer of training and the "external validity" of solutions is so dismal (e.g. Stolovitch, 1997). Since we seldom repeat transfer or impact evaluation on interventions that have been found to be effective in previous evaluations, we are not often aware of transfer failures. So, solutions which have been effective once, are touted to others who try them and are unaware that they do not work in a new setting. Concern about craft and technology has led to a series of reports from the National Academy of Sciences in the United States (Druckman and Bjork, 1990; 1994) on educational and psychological technologies and evaluations of craft solutions.

Finally, the third negative impact of craft is that the lack of a body of connected scientific theory about the problems being addressed, lead us to believe that science is irrelevant (or at best only a body of "opinion") and problems can best be solved in an ad hoc, intuitive fashion. Craft encourages fads, guru's and magical thinking about problems and solutions. The philosopher Dewey's attraction to science as a way to solve practical problems stemmed from his concern about our failure to provide teachers with effective strategies at the turn of the century. His concerns are still valid today. As a result of our failure to use science, he wrote, educators must ".... fall back upon mere routine traditions of ... teaching, or fly to the latest fad [or] panacea peddled out in ... journals...just as the old physician relied upon his magic formula" (Dewey, 1900, p. 113). Craft is based on the development of arbitrary, mechanistic procedures that are perceived to solve problems in a specific setting. Those procedures develop over time through trial and error adjustments in the problem-solving developed and implemented by experts in a specific context. Craft can be a very effective way to solve a problem. It allowed early human cultures to fashion fire on demand and build extraordinary monuments such as Stonehenge and the Inca cities of South America without the root sciences and mathematics that now serve engineers. It also permits organizational specialists to fashion policies and procedures that foster change and growth in specific situations and allows teachers to foster more-or-less random but sometimes extraordinary learning benefits for individual students or classroom based groups. Yet, the limitations of craft knowledge are not fully appreciated.

Clark (1988a), calling on the theories of Anderson (1993) and others (e.g. Rummelhart and Norman, 1981) has suggested that the lack of generalizability problem with craft mirrors the transfer problems we find in studies of human cognition. Craft mirrors a type of knowledge used by the cognitive system to overcome the limitations on working memory and thinking. When conscious knowledge is used to solve a problem, it gradually becomes automated and unconscious. This automated knowledge is used to make decisions, solve problems and perform all routine human activities. With procedural knowledge we have an efficient mental procedure that is highly effective only in very limited situations which ".. fail in general but work in specific cases" (Rummelhart and Norman, p. 338). This is the reason that craft is dangerous. It has a limited utility but people usually attempt to over generalize it without checking results. The fact that it is limited, context bound, generally inadequate yet effective in one setting, distracts us from real solutions to problems and leaves us overconfident about what we have accomplished. Yet, many educators are unaware of the transfer limits of knowledge and persist in believing that most expertise is widely generalizable. This leads to attempts to teach "learning to learn" and "analogical thinking" skills in schools when most research suggests that general reasoning and learning skills cannot be acquired by most students. When evaluation of these programs are negative, educators tend to blame technology. Thus, our unhealthy reliance on craft, and our tendency in the past two decades to call craft "technology", has eroded the support for educational technology.

One example of the problems created by craft are in the media selection area. Even the most recent model in this area (e.g. Cantor, 1988) is intelligently presented but like all past models, does not link advice to research on current cognitive theories of learning or instruction. Similarly, the most recent book on training and instructional design (e.g. Gagne & Medsker, 1996) suggests craft-based media selection procedures. Most professionals seem to support the intuitive correctness of instructional design and development models that propose connections between various media and different types of learning and information content. We do not doubt the occasional effectiveness of these selection schemes but are concerned about the reliability, internal validity and generalizability of the results. Media selection schemes are usually built on the intuitive assumption that any given media will support some but not other learning outcomes and information content. This assumption has been demonstrated to be incorrect since research has failed to establish any causal links between media and learning (Clark, 1983, 1994). The indirect result of this situation is that schools, government and industry often invest in newer media on the craft-based promise that "new technology" will improve learning gains.

What Is Educational Technology? Technology is a process whereby practical problems are identified and solved using interventions based firmly on sound scientific theory, principles and measurement. Scientific principles and the situations they attempt to explain are linked to a larger body of theoretical models that have been validated through systematic experimentation. Because educational scientists are concerned with both internal and external (ecological) validity, the results of an educational technology have the potential for generalizability and reproducibility. Landa (1983), in an very interesting discussion of the relationship between basic science and practical application, refers to the distinction between descriptive and prescriptive research. Another focus of a science-based technology is the value placed on the specification of the problem being solved. Since science must be clear about the problem being solved, a great deal of emphasis is placed on problem specification and measurement. This insures that causes and effects will be clearly defined and measured in a way that can be replicated. Finally, there is an engineering component to all social and educational technologies. Engineering strategies are the bridge between the problem, the science representing our knowledge about the causes and operation of the problem, and the intervention that is expected to solve the problem.

Examples of social and educational technologies are innovations such as the bail-bond process in our legal system (Reichen and Boruch, 1974); change strategies for self-destructive health and addition behaviors (Prochaska, Norcross and Diclemente, 1994), cognitive task analysis strategies for training and education (Clark and Estes, 1996) and John Anderson's (1993) ACT-R training design system and Anderson's (1993) tutor for the Lisp programming language. In each case, these technologies started with a practical problem whose solution was socially and economically valued. In the case of Prochaska et al (1994), addictive behaviors and self-destructive health habits are extraordinarily expensive components of our health care system.

The researchers associated with these technologies all started with the same barriers to overcome. First, they faced a profession where there were many dissimilar solutions available for the problem but none of the solutions seemed generalizable. In many instances, the available solutions seemed to work in one setting or with one type of person and cause greater problems for another (Prochaska et al, 1994). This seems to be the situation in instructional design where a variety of craft-based approaches to instruction can lead to measured learning gains for some students and learning content in one setting but lead to “learning loss” for other students, content and settings (Clark, 1988b).

What is wrong with technology solutions? So, if educational technology solutions are more robust and generalizable than craft solutions, why don’t we all embrace technology? As the dates on the citations for this article will demonstrate, the suggestion that we adopt technology has been around for nearly a century yet it has not been eagerly accepted. This implies that we have failed to solve some of its most important problems. In our view, there are at least three main barriers that inhibit the support for authentic educational technology -- non scientists cannot see themselves contributing to technology development; technology requires much more “front end” analysis of problems and impulsive problem solvers are not inclined to wait; and, we do not yet have an adequate process for translating scientific theory and principles into reliably effective technological solutions.

In the first place, people easily get the impression that only people who are trained and functioning as scientists can participate in technology development. Since the various social sciences are difficult to master and require experience monitoring developing bodies of research and theory, most people opt for craft. Craft solutions seem only to require strong analytical skills, creativity, focused motivation and expertise in the setting where the problem is being solved. In fact, as Kearsley (1998) has implied, the aptitudes required for the successful development of a craft are also the basis for most successful technologies. Even in engineering and medicine, various types of knowledge are required to realize the full development of a new technology. These skills include diverse areas such as communication and media production; graphic arts and drawing; computer systems and programming design and development; measurement and evaluation; and project management - to mention only a few specialities. Our beliefs about the levels and types of skills necessary to develop technology are inaccurate as a number of writers in this field have tried to point out over the years. Robert Heinich was not a scientist and yet he was one of the early people in our field who urged us toward a technology focus (Heinich, 1984). He was fond of pointing out that technology is, by its nature and complexity, a group process where everyone has a role in problem identification, intervention design, development, implementation and evaluation. What must bind us together is a commitment to science-based problem and a belief that we can effectively coordinate our separate contributions to the end result.

The second issue that inhibits our support for educational technology is that it takes considerably longer to develop a technology than to devise a craft solution. The extra time is often required at the beginning of the process in order to insure that the real problem has been identified and that the science used for the solution is connected to the problem in prior research and theory. It also requires that impatient educational managers resist their inclination to suggest and implement solutions before problems are thoroughly validated and metrics are available to measure impact. Our experience suggests that most educational problem descriptions are brief and inadequate and most solutions are selected and implemented before there is an adequate understanding of the problem context. Since careful evaluation of results is a rare event, we find that having a solution underway or implemented is considered a successful achievement by most educational managers. If structural engineers and architects worked the same way, most of our buildings would sink into soft ground, be destroyed by earthquakes or other natural disasters and/or fail to serve the needs of those who work in them. Part of the reason for this impulsiveness is a public or a business environment that wants "results" quickly. Since we seldom compare the costs and benefits of craft and technology, we do not have rational data to offer in defense of the careful front-end analysis required by technology. Clark (1994) has provided such data in a rare study comparing a craft and a technology approach to the solution of a knowledge problem in a European organization. He found that while a technology-based training approach required 30 times more front-end effort than its craft predecessor, the technology was so efficient that its delivery and impact cut the time required to implement the solution by half and therefore the financial cost was about half as much as the craft approach. In addition, the technology solution was available for transfer to other parts of the organization and was successfully transferred to different organizations.

The third barrier to the continuing development of educational technology is that we have not yet found an adequate system for connecting basic research, practical problems and the constraints that face interventions in modern educational organizations. We know that we cannot simply "apply" research findings to practical problems and solve them. We need to develop a process that is similar to the "scoping" strategies in engineering or the "diagnosis and triage" approaches used in medicine. There are many first hand accounts of such strategies (see for example, Prochaska et al, 1994) but no systematic study of the issue. We will have much more to say about this issue in a later article in this series. Before this problem is addressed, we need to briefly examine the reason technology is resisted by educators.

Why do educators generally resist technology? Fred Kerlinger, whose books on research methodology have trained generations of students, suggested that educators have actively resisted research-based principles in the past because "Educators have little patience with what they conceive to be 'impractical, ivory tower' research ... the net effect of their impatience is a pervading anti-intellectualism that has a devastating effect on research in education" (Kerlinger, 1977, p. 6). Robert Heinich went even farther when he provided evidence that teachers will resist instructional technologies (one of the many categories of educational technology). He wrote that "organized teacher activity parallels the craft union movement in industry. The ways in which the labor movement tried to protect its members from the encroachment of technology are very similar to how teacher groups seek to maintain the labor-intensive character of instruction (Heinich, 1984, pp. 77-78). Katz (1966) describes the historical development of the craft versus science split in Schools of Education. He argues that early in this century, due to their craft focus, "...educationists rejected the option of adherence to any one of the established scientific disciplines, proclaimed themselves to be outspokenly eclectic, and failed to develop a distinctive mode of inquiry or a set of criteria for organizing data for their self-proclaimed science. In the process, they lost all criteria for limiting the nature of their inquiry and instead, tried to construct a discipline through an indiscriminate survey of all factors loosely associated with schools [and]... became marked by the survey outlook" (p. 332). In the process, Katz argues, education preserved some of the surface trappings of quantitative measurement and science, but cut itself off from advances in scientific methodology; ignored technology development in related professions; severed theoretical connection to related disciplines; and maintained its primary emphasis on craft. The recent emphasis on "post-modernist" philosophy in education is simply the most recent manifestation of a long tradition.

Summary and Conclusion

We believe that our field is producing craft and calling it "technology". The result of this confusion can be found in a number of distressing research and evaluation reports on the lack of effectiveness of many of our popular interventions. Reviews and methodological studies of our work suggest that too many programs are based on ad hoc, non transferrable and isolated solutions to problems that often do not represent the ones we were trying to solve. Yet we are presenting the solutions as if they were effective, derived from scientific theories and models and generalizable to different people, tasks and contexts. When adequate measurement and evaluation establishes that solutions we believe to be science based do not generalize, our reaction has often been to reject science and research as "mere opinion" and foster qualitative evaluation strategies that give us the results we expected. It is too often the case that these rejected solutions were ether "scientized" craft or poor technology. These negative results are very dramatic at a time when educational technology (when defined as media and distance education) is experiencing very enthusiastic international support. Complicating this picture is a distressing tendency for educational technology graduate programs in universities to drift farther and farther away from science over the past two decades. This trend is in the opposite direction from developments in fields such as medicine and engineering where, along with the National Academy of Sciences, we agree that technology is more secure in recent decades. We suggest that part of the reason for our problem is that craft solutions can be developed with little or no training or commitment to science. Since robust evaluation is seldom implemented in educational settings, we tend to be unaware of the transfer failures resulting from attempts to generalize craft solutions. In addition, the technology of education has not yet been fully developed and the necessary participation of non scientists has not been planned or encouraged. Yet we must find ways to encourage increased attention on a wider definition of educational technology. Only with a science-based technology will we be able to produce reliable, generalizable and effective solutions to educational problems. In our next article, we will review accounts of technology development strategies. Our goal is to foster the systematic development of a true educational technology by people from a variety of non-scientific backgrounds and expertise.

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