Essay: Applied Instructional Design

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"Applied" instructional design: what does the phrase mean? To some academics, applied evokes an image of the manufacturing floor: oily rages, smell of grease, blue lab coats, dirty fingernails, just production. There are no F-tests here, and no significance except that the product had better work when it rolls off the floor. It's the term "applied" that conjures this false image.

Every field remotely related to technology (e.g., engineering, chemistry, physics, business, law, medicine, etc.) has a sub-field that uses "applied" in its name. Just pick the name of any academic field and Google it with "applied" attached and see for yourself. In Computer Science there are degrees in Applied Computer Science. In the social sciences there is a Society for Applied Sociology. For kicks, do this with "archaeology".

What does "applied" mean in terms of practice? What does it mean in relation to theoretical issues? What does it mean for research?

The mission statement of *JAID* states:

> *The purpose of this journal is to bridge the gap between theory and practice by providing reflective scholar-practitioners a means for publishing articles related to the field of Instructional Design.*

That's pretty general. Does it refer to research articles? Development reports? Essays like this one? Opinion pieces? Technical Notes? There's more:

> *JAID's goals are to encourage and nurture the development of the reflective practitioner as well as collaborations between academics and practitioners as a means of disseminating and developing new ideas in instructional design. The resulting articles should inform both the study and practice of instructional design.*

There's the divide in our thinking between the "academic" and the "practitioner". It would profit instructional designers to examine this gap in hopes of being more specific about the niches and habitats that exist within the world of instructional design and how designs evolve gradually to become artifacts.

Three years ago in this journal, Ellen Wagner (2011) addressed essentially the same issue in a slightly different way:

> *So I ask you this very pointed question—What do YOU think an ID should be able to do? Are we technologists? Psychologists? Evaluators? Programmers? DO we need business skills? Theoretical cognitive skills?* Are we artists or engineers or a little of everything in-between*? (p. 37, emphasis added)*

If we are going to search for an answer to her question (and mine), we should agree from the start that there is not a single "right" answer. There is nowhere written in tablets of stone a formula defining the proper organization of work and skills and knowledge within a field of design—not even instructional design, which has fallen into some very inflexible and hard-to-change patterns. In fact, any observer today will readily recognize that there is really no such thing as a "field" of instructional design, except as people decide to call themselves instructional designers. We are not after truth here, rather utility, and it may be that the classical categories Wagner names aren't as relevant to progress as her "everything in-between".

To illustrate this, I would like to relate some history from another technological field that provides food for thought about what applied instructional designers do. The setting is the tool steel industry, and the time period is roughly 1895 to 1905. Within this ten-year period a body of research performed in America revolutionized the world's tool steel industry. It took the work of two unlikely actors working in a totally unconventional way in secrecy, trying to solve a problem of volume in steel production.

Frederick W. Taylor—who later gained fame as the efficiency expert who invented modern management practice—was hired in 1898 by Bethlehem Steel in Pennsylvania to solve a particular problem: production of ordinance (military) steel was experiencing bottlenecks, and output was unacceptably low. Taylor solved the problem, in a way described in detail by Misa (1995), as summarized below.

Taylor's goal was making hardened steel cutting tools that could machine (i.e., mill, turn, cut, chip, plane, etc.) softer steel. This was a problem of bootstrapping, because as soon as you made harder steel, there had to be some steel even harder to shape, cut, and work it.

The financial implications of this problem clearly made it worth researching, but there was at the time no discipline of materials science; the scientific discipline of metallurgy was in infancy and had little to contribute. Steel making during this period was based almost entirely on received guild practices and expert-practitioner intuition, aided by tool concepts that were very old. There were few standards of practice or of product quality other than those taught by masters to apprentices. Though the steel industry was booming, there was great variability in the quality of the product, even within product categories, such as rail steel, or structural building steel. Railroad, bridge, and structural accidents were common.

One of the barriers to improvement of steel making practice was reliance on methods and processes that had been developed based on intuition and experience that evolved into tradition within an apprenticed system of steel makers. This body of "knowledge" evolved over decades without the benefit of systematic empirical study and measures and with only crude measures of process and product quality.

This tradition was completely contrary to the temperament and disposition of Frederick Taylor, who began a systematic study of how to make hardened steel with measurable qualities. Teaming with Bethlehem's testing engineer Maunsel White, Taylor pursued a process of research that can best be compared to the recent phenomenon of design-based research (Kelly, Lesh & Baek, 2008; McKenney & Reeves, 2012). Today, in an industrial setting, this would be called "research and development". The research proceeded in stages, each of which used a particular method, and each of which produced a certain kind of knowledge.

Taylor questioned the received wisdom about the amount of heat used in preparing hardened tool steel and the method of using the color of the steel during a melt for measuring progress. He heated one crucible steel melt to "bright cherry" and other melts to "dull salmon", "salmon", bright salmon", and "yellow".

This was not research based on a theory using a hypothesis: it was a fishing expedition. But it worked for Taylor, and the results were stunning. The lowest of the heats—bright cherry—produced steel of inferior quality, as the traditional wisdom would have suggested. However, Misa (1995) relates that, "received wisdom was shattered by the tools treated at the three highest heats" (p. 187). The higher-heat tools cut at remarkable speeds and for much longer periods of time. By "fishing" Taylor had been led into new, unexplored territory.

It is important to reflect on the difference in the nature of Taylor's research at this point from the hypothesis-centered research instructional design students are directed to. Taylor was not proceeding in his research according to the dictates of a specific theory. In his own words he describes how:

> *This accurate practical heating and running of tools (*without any theory on our part as to the chemical or molecular causes which produced the extraordinary phenomena*) led to the discovery that marked improvements in the cutting speed…were obtained by heating tools up close to the meting point. (Quoted in Misa, 1995, p. 185, emphasis added)*

Taylor not only demonstrated the existence of an effect, but with White he began to map out the unknown territory. Rather than acting like an explorer wandering through the west, noting a few impressive features, Taylor and White began to act more like settlers, with their surveying parties, mapping the terrain in detail.

Taylor's measurement initiative and its instruments were a new cultural phenomenon in the steel mill, which had traditionally relied on visual inspections and subjective judgments by "experts" about the temperature of the metal as indicated by its heated color.

No wonder there was so much variability in the quality of steel. In the daytime, "bright cherry" might be the expert's judgment; the same melt at nighttime might be declared "dull salmon". Taylor realized that ambient conditions of light and weather influenced "expert" judgment of steel melt temperature. Therefore, he and

White implemented standard measures and standard instrumentation. A modified pyrometer (high temperature measurement tool), while it was somewhat temperamental to use with accuracy, surpassed the traditional visual inspection.

As the accuracy of temperature measurement went up, so did the consistency of the steel quality, and so precision increased. Multiple readings of a melt by multiple technicians using the pyrometer reduced the variability of measurements. As Misa (1995) reports, "the *heat* "light cherry" became the *temperature* 845°C, or 1,553°F" (p. 191, emphasis in the original).

Taylor added a second set of experimental variables at this point related to the cooling, or tempering, process of a melt. The new variables included cooling temperatures, timing, and quenching material used to bathe the cooling steel. By bringing temperature measurement and the variables of the tempering processes together under control, Taylor and White possessed the research process they needed for an extensive series of approximately 16,000 systematic studies conducted over roughly nine months. Their method was to manipulate the value of a single variable while holding all of the others constant.

This amounted to an enormous body of research. Rather than trying to confirm of disconfirm an explanatory theory, it sought to define the *terrain* of a previously unknown area of practice. This research was directly analogous to that of the Wright Brothers conducted only a few years later as they explored the best values wing and propeller shape for their aircraft (Combs, 1979). Ironically, both Taylor and White and the Wrights learned from their data that the received "scientific" guidance of tradition was flawed and had to be corrected through painstaking experimentation. This research did not just demonstrate the existence of a relationship, but rather it charted the full surface of that relationship as defined by the intersection of a number of variables and a desired outcome.

Taylor and White were successful at defining such a surface with respect to the application of their hardened tools to lathe work on steel. The full surface of this set of variable relationships was so well defined that Carl G. Barth, a member of Taylor's research team, was able to construct a slide rule by which lathe operators could calculate for a particular piece of steel to be machined the best set of feeding speeds, depth of cut, and turning speeds that would lead to the most efficient use of the lathe (see Figure 1).

The body of technical data amassed by the Taylor-White experiments (and the Wright experiments) represents just one of the types of knowledge described by Vincenti (1990) as being essential in the practice of design. Such bodies of data on materials, their properties, and their operating characteristics are *sine qua non* in modern engineering design. Comparable bodies of technical data are virtually nonexistent for instructional design purposes. This constitutes a type of finding that would be natural for *JAID* publication.

Any reasonably competent mill supervisor could apply the wealth of technical data Taylor and White produced. The control that intuitive "experts" had exerted over the quality manufacturing process was transferred to the minimally trained worker employed by a licensee to the Taylor-White data and formulas for applying them. This was licensed in the form of a recipe package in which key process actions and ingredients were encoded and packaged separately so that only authorized users would have access to the full recipe.

Ironically, Bethlehem fired Taylor after only 2

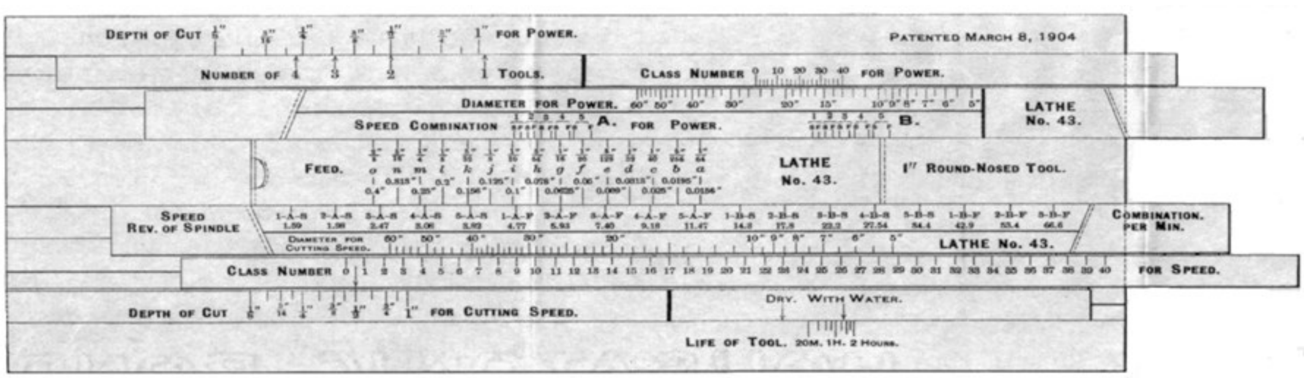

Figure 1. A machine-time slide rule with five movable members for calculating optimal feed rates, machining speeds, and cutting for lathe machining of steel using hardened tools. *Journal of the Oughtred Society*, 9(2), 34.

years and four months (because he caused "continuous strife", which was a personal characteristic eventually noticed by others than Bethlehem), but his work with White placed the hardened tool steel industry on a new kind of "scientific" footing that in a very short time revolutionized the entire industry. Misa (1995, Chapter 5) refers to this epoch of change as the "reform of factories". This "science" dealt with theories, but they were not grand explanatory theories that tried to make sense of the world: they were theories that later could be used to link the grand theories that emerged later with actual practice. They were *technological* theories (Gibbons & Rogers, 2009).

In the end, steel production rates for tool steel increased in the range of 200% to 300% due to the Taylor-White research, and the quality of steel products, which had been highly variable before, became much more predictable. Before long, it became apparent that "the new steels demanded factory-level modifications" (Misa, p. 194). This is also a story the instructional design community should be interested in, but that would require another essay.

Conclusion

This essay began as a comment on the meaning of the term "applied" as it appears in the title of this journal and the distinctive mission this journal has to perform. The term "applied" in the case of Taylor and White meant much more than just producing a product—getting your hands dirty, embodying someone else's ideas, creating code and images. Beyond just the interests of the journal, my point is that I believe we have trivialized and overlooked a body of theory that is required to apply high-level instructional and learning theoretical principles during design. On the one hand we are used to talking theory, and on the other we are used to using the keyboard and mouse to turn out a product, but there is a place in the middle that we tend to ignore. It is the middle ground between thinking in theory and making something that actually applies theory. It is the place where sometimes to link theory and application we have to perform additional research like Taylor and White that gives us the additional theory and data we need to make an effective application to individual cases that still respects the operational principles of the high-level theory.

In this middle ground, we figure out specific means in practical terms for how to divert or influence natural learning processes in the direction of chosen purposes. This is a broad ground, not a direct path, and there are degrees of "right" in this middle ground. This means that the conversion of theory into practice is not direct. It means managing multiple variables in a space like the one Taylor and White (and the Wright Brothers and *many* others before them) had to explore in detail because no one had explored it before. It involves sometimes experimenting in a way that produces a matrix of relationships and data—a surface—rather than simply demonstrating a relationship between variables. It means learning new theoretical relationships that are technological in nature, not scientific.

I believe that as we talk about instructional research and theory in our literature we largely omit consideration of this middle ground. We write, for example, as if a single instructional theory (i.e., case-based or problem-based learning) or learning theory (e.g., constructivism or direct instruction) could provide sufficient discipline to guide the creation of a single entire design. On the contrary, every design requires that we "apply" multiple theories—theories of content structure, of interaction strategy, of user controls, of message structure, of representation, of data collection and management, and of media execution (Gibbons, 2014).

We apply all of these kinds of theory without thinking in detail how they have to be integrated into a nuanced, harmonious design. Worse, we do not think of these theories of application as being distinct and having an identity separate from learning theory or high-level instructional theory. Because of this, much of our designing today consists of modeling on other designs rather than thinking through the integration of *all* of the theoretical principles that we are trying to apply in a design.

We appear to assume that by dubbing a design with the name of a prominent instructional theory we actually are applying the theory in a valid way. There is evidence that this is not the case and that the application of theory during design requires a great deal more discernment, rationalization, and bridging theory than we had expected (see, for example, McDonald & Gibbons, 2009). But in technological matters there are no "right" ways: there are only good ways and better ways.

The community of instructional designers should pay more attention to this middle ground of application theory. Its nature is different from scientific theory (Gibbons, 2003). It has been described by Simon (1999), Bruner (1966), and many others (see Glaser, 1976 for an excellent example). It is described in some detail by Vincenti (1990), who points out the multiples categories of theoretical and practical knowledge required by the designer (see especially Chapters 7 and 8). These are required—and applied—whether the designer is aware of using them or not, so it will be of benefit for designers to become aware of them.

Because this is an essay, I have taken the liberty that essays permit of expressing my opinion. However, I have tried to use the example of Taylor and White (and of Wilbur and Orville) to point out that this opinion is not just feverish thinking produced by a deadline.

Is the instructional design community (in all of its habitats and niches) ready for the kind of revolution that would be caused by emphasizing the type of research and theorizing suggested by the example of Taylor and White? Is there currently research that is creating databases that describe the surfaces created by the intersection of instructional variables in the same way the steelmaking example described the surface at the intersection of temperatures, timing, and tempering additives? There are several questions involved: Should it be done? How would it be done? What would the research questions look like? What would the research designs look like? What combination of research methods would/could be used? How would the community identify and prioritize the most impactful questions? How would the research be organized? Would it require the formation of collaborative cooperatives for programmatic research rather than individual doctoral studies? Could doctoral studies be made more meaningful in the context of such research programs? And who would fund it?

However these questions are answered, the results of the research should be published in a journal with a title like, *The Journal of Applied Instructional Design*.

References

Bruner, J. (1966). *Toward a theory of instruction.* New York: Norton.

Combs, H. (1979). *Kill Devil Hill: Discovering the secret of the Wright Brothers*. Boston, MA: Hougton Mifflin.

Gibbons, A. S. (2003). The practice of instructional technology: Science and technology. *Educational Technology*, 43(5), 11-16.

Gibbons, A. S. (2014). *An architectural approach to instructional design*. New York: Routledge.

Gibbons, A. S. & Rogers, P. C. (2009). The architecture of instructional theory. In C. M. Reigeluth & A. Carr-Chellman (Eds.), *Instructional-design theories and models, Volume III: Building a common knowledge base*. New York: Routledge.

Glaser, R. (1976). Components of a psychology of instruction: Toward a science of design. *Review of educational research,* 46(1), 1-24.

Kelly, A. E., Lesh, R. A. & Baek, J. Y. (2008). *Handbook of design research methods in education: Innovations in science, technology, engineering, and mathematics learning and teaching*. New York: Routledge.

McDonald, J. & Gibbons, A. (2009). Technology I, II, and III: Criteria for understanding and improving the practice of instructional technology. *Educational technology research and development*, 57, 377-392.

McKenney, S. & Reeves, T. C. (2012). *Conducting educational design research*. New York: Routledge.

Misa, T. J. (1995). *Nation of steel: The making of modern America, 1965–1925.* Baltimore, MD: Johns Hopkins University Press.

No author (2000). *Journal of the Ougthtred Society*, 9 (2).

Simon, H. A. (1999) *The sciences of the artificial (3rd ed.)*. Cambridge MA: MIT Press.

Vincenti, W. (1990). *What engineers know and how they know it: Analytical studies from aeronautical history*. Baltimore, MD: Johns Hopkins University Press.

Wagner, E. (2011). Essay: In search of the secret handshakes of ID. *JAID*, 1(1), 33-37. (p. 37)