ISD and Functional Design Layering

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This chapter has two purposes. First, we contrast two approaches to instructional design—the traditional Instructional Systems Design (ISD) process and an alternative view known as Functional Design Layering (FDL). In our review, we describe the background of each approach, the problem(s) each approach attempts to solve, and the types of decisions each approach prepares instructional designers to make. Second, we show how these different approaches play complementary roles in the practice of instructional design. When considered together, they offer a more robust conception of how instructional designs can be created. Essentially, ISD focuses on design process at the expense of internal design structure, whereas FLD focuses on internal design structure and proposes a naturalistic view of design decision order that is more closely aligned with actual designer practice. Considered together, these contrasting approaches become mutually strengthening, providing the designer with a wider range of design questions and design process options.

Instructional Systems Design: Origins

The focus of Instructional Systems Design (ISD) is on ensuring instructional designers follow a process that will enable them to create powerful instructional (or learning) systems. Its foundations can be traced to the book *Psychological Principles in System Development* (Heretofore referenced to as *PPSD*) (Gagné, 1965). Here, Gagné described training and education systems as "man-made 'synthetic' organisms, whose components, subsystems, and interactive mechanisms have analogous functions to those of biological organisms . . . " (Gagné, p. 12). If there was an enduring idea in the original expression of *PPSD*, it was the concept of a system as an organic, adaptive entity, with the system's functions being the point of departure for design.

> *Planning for the development of a system begins with a series of decisions regarding the functions to be performed by various parts of the system in their subordinate contributions to a total complex which will accomplish system goals. (Gagné, p. 34)*

Gagné was proposing that the basis for system design was an inventory of the functions the designed system would perform. However, a gradual shift in the interpretation of the term "function" that occurred over time was pivotal in shaping the eventual form of ISD. Chapters of *PPSD* were weighted heavily in terms of design processes, so it became accepted that *design* functions—as opposed to *system* functions—should be the more central concern. Processes like target population analyses, task analyses, and the selection of media came to predominate the design approach; the study of internal instructional artifact functionalities such as content and strategy structuring, message and learner control design, and message representation became secondary.

The theme of "systems development" from *PPSD* was amplified over several decades by Gagné and many of his colleagues, morphing over time into the "systems approach" to instructional design. What resulted was a body of design process prescriptions that is still the dominant approach taught in graduate-level instructional design programs and commercial industrial training manuals (Curry et al., 2021; Etmer et al., 2013; Gagné, 2004).

instructional design industry (Briggs et al., 1991; Dick et al., 2009; Gustafson, 1981; Gustafson & Powell, 1991; Heinich et al., 1996; Kemp, Morrison, & Ross, 1994; Reiser & Dick, 1996; Smith & Ragan, 1999). To aid widespread dissemination of ISD models, it became necessary to simplify them for a variety of non-academic audiences. For example, the multi-volume *Interservice Procedures for Instructional Systems Development* (Branson et al., 1975) attempted to place instructional design practice in the hands of untrained military and government designers. This, and other likeminded process descriptions, were used to train a large number of novice designers in military and government service who, after gaining a degree of experience, eventually found career paths leading to general commerce and industry.

There were many beneficial outcomes from the widespread dissemination of ISD models: project management became more predictable because design was packaged as a set of standard processes; design projects became more schedulable and manageable; designers with minimum training could gain entry to a career path with a reasonable threshold that did not require a specialized degree; and the training function itself could be assimilated by large training organizations as a source of improved workforce performance. Design defined as a collection of processes proved to have many uses, and the domination of the field by an engineering frame of mind—unbalanced by alternative views—lasted until the 1980s and 1990s, when a more searching view of design processes independent of disciplines became a topic of intensive study.

Alternative Approaches to Design Emerge

ISD emerged in an environment where many design fields (e.g. architecture, product design; see Cross, 2007), not just instructional design, were dominantly focused on a process-centric approach to systems development (Banathy, 1968; Briggs, 1967; Diamond, 1997; Hamreus, 1968; Gerlach & Ely, 1980). However, in many of these fields, alternative ways of thinking about design started to emerge and found popularity as process models were found to be inflexible in some applications and generally untrue to the natural decision-making patterns of designers in practice. Systematic design models logically begin with multiple analyses for a complete survey of the design and implementation environment, including user demographics, existing resources, resource constraints, and even organizational politics. But, in practice, designers don't wait for analysis results before they begin to hypothesize the broad outlines of one or more possible design configurations. Moreover, designers found that these design hypotheses feed back into the analysis process, leading to further analysis to support or cancel a particular design hypothesis. Schön (1987) refers to this as the "conversation" (p. 43) between the designer and the design problem: a back-and-forth exchange between analysis findings and design hypotheses, with hypotheses leading to further analysis.

Alternative approaches to design became a current topic in many design fields in the 1980s and 1990s, as design itself became a topic of study, promoted by the work of Simon (1999), Alexander (1964, 1977), Jones (1970), Darke (1979), Schön (1987), Kelley (2005), Dorst (2011), Cross (2018), and others. Even in engineering fields such as aviation design, researchers like Vincenti (1990) recognized that the exact nature of design questions and goals was refined in the process of making designs that worked. Schön's description of the reflective practitioner showed the designer studying the internal structures and functions of designed artifacts in terms of design languages describing artifact functions rather than design process functions.

The foregrounding of *artifact* functions and design thinking not only raised questions about how designers solve problems, but also questions about the nature of designs themselves. Darke (1979) proposed the concept of the "primary generator" of a design, a structural concept around which the remainder of the design could coalesce. Schön (1987) and Reinfrank & Evenson (1996) described the concept of design language and suggested that function-specific design languages existed within the "layers" of a design. Separation of functional layers in the design of computers, software, and architecture (Brand, 1994) echoed this concept, describing how the modularization of designs made possible by layer structures gave the designed artifact a longer service life, since changes could be made to layer designs with minimal disruption of other layers. An extended case study of layered design by Baldwin and Clark (2000) showed that layered or modularized designs made the escape from computers with monolithic designs possible, design layering based on artifact functionality is found today in virtually all design fields and provides major economic benefits. Today, fields that do not consider design layers and the modularity they afford are denied access to product maintainability and the attendant economic value.

Revisiting the Interpreting of “Function” in Instructional Systems (Functional Design Layering)

Fresh ideas about design and design theory have been slow to reach the instructional design field. There have been critical reviews of ISD and its dominance (Bichelmeyer et al, 2006; Gibbons et al, 2010, 2013, 2014; Gordon & Zemke, 2000; Merrill et al., 1990; Smith, 2008; Smith & Boling, 2009), but alternatives to ISD as the sole approach to design have been slow to emerge and find a place in academic literature and academic design programs. This may be due to an early (mis) interpretation in the field, where the term “function” was used to refer to “design” function. Revisiting Gagné’s original description of “function” as expressed in *PPSD* would lead to a much different view of instructional design today, if it referred to the functional elements of the artifact being designed as well as the functions of designing. The ISD model focuses the designer’s attention on functions performed by the designer; instead, we might also consider the functions carried out as subprocesses within the artifact being designed.

Gagné originally suggested that:

> *Because of the nature of a synthetic organism, the functioning of its parts and subsystems may be studied directly, thus providing a means of developing systematic accounts of the processes of interaction within the system as well as their effects on total system functioning. (Gagné, 1965, p. 12)*

Focus on the functions of the “organism” opens a new perspective on instructional design and the act of designing instructional experiences.

A functional (or architectural) theory of instructional design proposed by Gibbons (2009, 2014) takes this approach. To create organic designs—designs that can change and adapt dynamically with changes in external conditions—one must consider the functions performed by the “organism” itself—the artifact being designed. Brand (buildings) demonstrates that buildings possess life-extending properties if they have been designed according to a separation of functional “layers,” each layer being a functional design subproblem: exterior skin layer design, separate from an interior spaces design; the separation of services design (electrical systems, plumbing) from the design of supporting structures and foundational elements (Figure 1).

A functional approach of this kind does not preclude the parallel use of a process-centered design process model; it enhances it by offering the designer a more flexible approach to the ordering of design decisions and analyses.

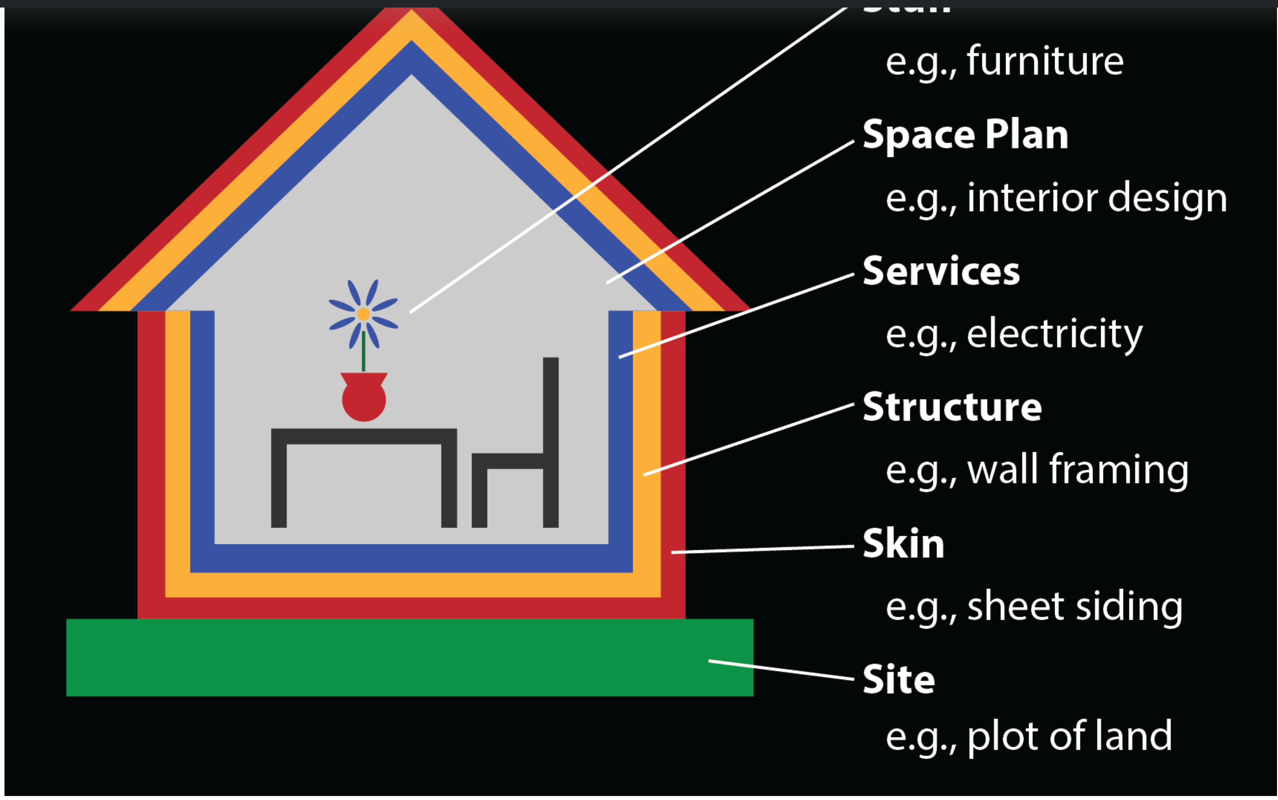

Figure 1. The Layers of a Building's Design (adapted from Brand, 1994).

An automotive design team will approach the design of a new car with a process model in one hand and a description of the functions of the automotive product in the other. The process model makes design manageable, while the functional artifact model points out the very substance of the design. Functions of an automobile artifact design include certain essentials such as propulsion systems, traction systems, braking systems, and steering systems. Each of these systems is supplied with the language terms related to each layer of the design: "engine," "wheel," "brake." These are designable artifact elements, and a specialist in designing one part will know the language of that part's design. Each layer design over time decomposes into subsystems (e.g., "brake pad" or "caliper") to be designed. This artifact-focused approach is equally valuable and equally as valid as the process approach. The approaches complement each other with their strengths.

Gibbons (2014) proposes a list of generic instructional functions as a minimal set for instructional artifacts. These include:

- The formation of sequenced packages of elemental **message** packets to provide substance for the formation and projection of representations (a Message Layer)
- The description of the **device means** and a **device-related language** for use by the learner in communication of messages back to the instructional source (a Control Layer)
- The definition of instructional/experiential **events** and a plan for their sequencing (a Strategy Layer)
- A system for describing and capturing constituent parcels of **“knowables” and “performance expertise”** (a Content Layer)
- A system for **recording and analyzing** interactions and learner action patterns (a Data Management Layer)
- Directions for operating the experience-enacting **delivery platform** or mechanism (human or computerized) capable of bringing together and coordinating events, content parcels, message and control elements, representations, recordings, and analyses (a Media-Logic Layer).

Seven Basic Layers for Instructional Systems

Each instructional function in an artifact can be described in terms of a layer, or a specific design problem to be addressed. Gibbons (2014) proposed seven basic layers for instructional systems.

Representation layer – The parts of instruction that learners directly see, hear, touch, etc. (seeing an image on the screen; hearing a voice explain a concept).

Message layer – The underlying instructional intentions that are given concrete shape by various representations (the intention behind explaining a procedure; the intention behind presenting possible actions and consequences).

Control layer – The ways learners act in the instructional environment (using a keyboard to enter text into an online form; raising a hand to alert a teacher they want to speak).

Strategy layer – The plans for instructional events and interactions, along with the sequence of how learners experience those events/interactions (explanation-demonstration-practice; solving authentic problems).

Content layer – The underlying subject matter that forms the “raw material” of instruction (a skill to be performed; a body of knowledge to master).

Data management layer – How information about the instruction is gathered, stored, analyzed, and reported (how much time learners spent in a system; students’ scores on a test).

Media-logic layer – How all the other layers are brought together, coordinated, and adjusted throughout instruction (learning management systems; computer operating systems).

It is proposed that this list of functions represents an essential abstract of the instructional artifact. These functions are performed to facilitate instructional experiences, regardless of the delivery medium chosen by the designer, the designer’s instructional philosophy or strategy preference, or their preferred theoretical stance. Therefore, they represent a core of artifact functions to be designed. As in the automobile design example, each layer of the design poses questions and choices. This makes available to the designer a variety of design language options for each layer and associated theories of representation design, message formation and interaction, control design, and so forth. Most importantly, it makes the designer aware of a host of design questions that under a process design approach are defaulted because they do not always appear to the designer as choices.

theory agnostic, accommodates the designer's preference for instructional theory. The basic inventory of layers (and sublayers) described above does not change with advances in theory and technology as much as it is added to, detailed, and subdivided by them. New discoveries may add new sublayers and design specialties, but there is always the need for a representation function, a message formation function, a control function, a strategic function, and a function that parcels out elements of the knowledge and action constituents.

The Relationship of ISD and Functional Layer Design (FLD)

ISD & Functional Layer Design (FLD) differ in the way they define the design problem. ISD refracts system design functions through a process prism, breaking the problem down in terms of *design process* functions; FLD refracts system design through the artifact's prism, breaking the problem down in terms of the artifact functions to be designed (Figure 2).

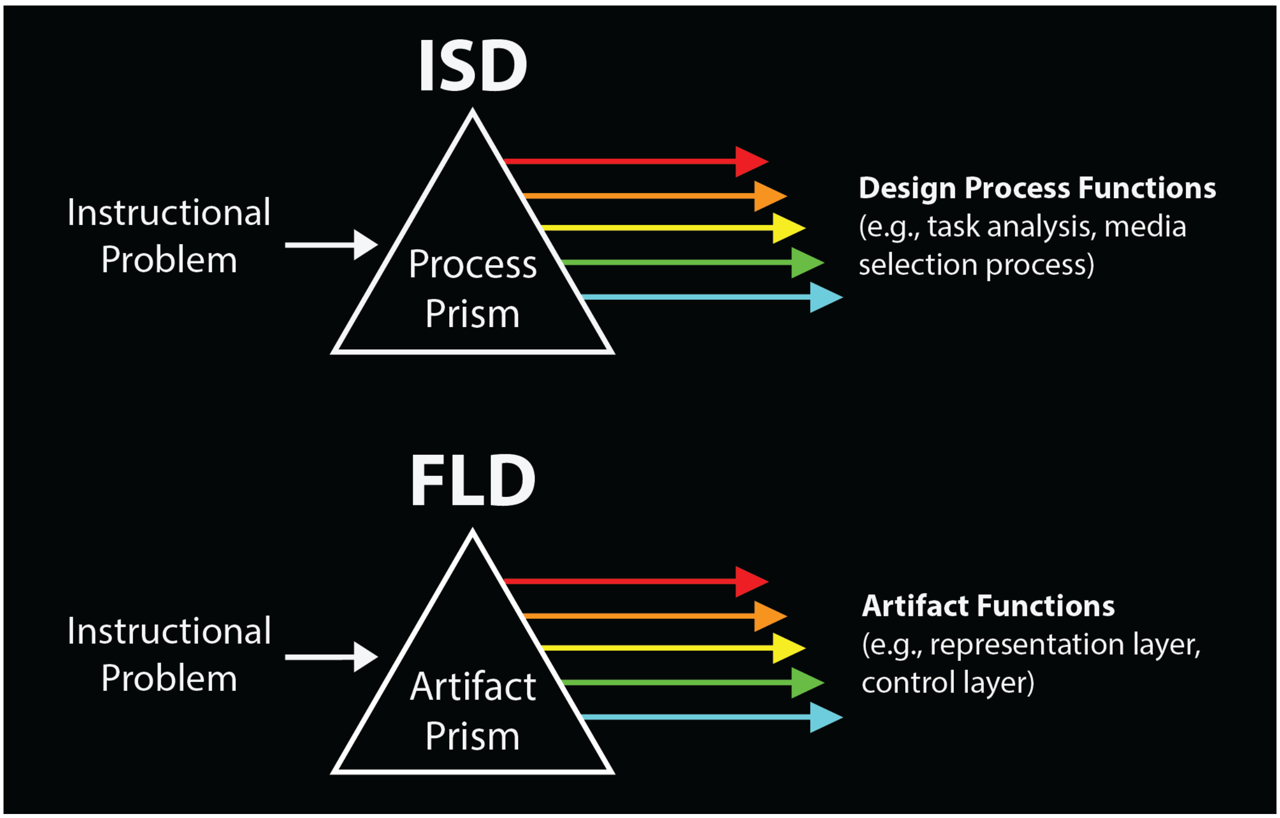

Figure 2. The Differing Lenses of ISD and FLD

For example, whereas ISD specifies a general logical order to design processes, the order of design decision making in layered designs is not sequential in the same sense. It is not necessary—and in some cases may be counterproductive—to adhere to a strict delineation of analysis, design, development, implementation, and evaluation phases. Instead, design can proceed according to and within the most important constraints and fortunate opportunities (Baldwin & Clark, 2000; Gross et al., 1987; Norman, 2002). The design decisions to be considered first depend on the constraints given with the design problem. Often design decisions related to a particular layer come ready-made, as in the case of a media constraint or a client's preference for strategy.

Design decisions within multiple layers may be advanced (after a sufficient amount of analysis) at the same time as joint hypotheses and tested and then modified and retested. New constraints result from the making firm of a particular configuration of layer properties. These in turn limit the range of choices left open for the designer. Design proceeds in the level of detail the designer selects. This is an especially useful principles that allows higher levels of the design to be completed by a designer, leading to additional design details to be filled in by layer specialists (e.g., artists, programmers, writers, experience designers, and editors). During this unfixed order of decision making, principles of design thinking can be explored, and the order for making decisions becomes tailored to the problem's context.

However, because of these contrasting approaches, ISD and FLD are actually mutually strengthening. The process view of design leads to the exploration and improvement of design processes; it reminds the designer that the creative process must be, at the same time, manageable. The artifact view leads to the exploration of the inner structures of artifacts and reminds the designer that the details of designs interact at many levels with theories of cognitive processes and instructional theory. These seemingly antagonistic approaches should together redefine our approach to designing and open new avenues to the design thinking of other design fields to sharpen and clarify the concepts we pass on to a new generation of designers.

Understanding the functional layers within an instructional design offers you conceptual resources to describe at a great level of precision how and why the design works as it does. The purpose of this activity is to practice analyzing a design from the perspective of the layers of which it is composed. It will also help you explain the different kinds of decisions ISD and FDL allow designers to make.

1. Identify an instructional design you are currently working on or that you have worked on recently. This could be a class project or an assignment from your place of employment. If you do not have a ready design to analyze, identify one with which you are reasonably familiar (perhaps a piece of instructional software or an online course you have recently completed).
2. Consider the design from the perspective of ISD, or, as discussed in the chapter above, the "functions performed by the designer." In a brief list, specify the decisions that ISD has helped, or could help, you make in service of completing this design. If you need assistance making your list, see this chapter on instructional design models elsewhere in this book.
3. Now consider the design from the perspective of FDL, or the "functions carried out as subprocesses within the artifact designed." Create another list that identifies at least one meaningful function in each of the seven layers described in this chapter. Also consider: are there other layers in this design that perform a function distinct from the basic set? If so, identify them and the function they are performing.
4. Compare your two lists. What are the differences? Are there any similarities?
5. In a short reflection (2–3 paragraphs), summarize what this activity illustrated about the purposes and benefits of FDL. Take into account questions like: What does examining a design from the perspective of FDL offer that other perspectives (like ISD) do not? What do you think it means that, together, ISD and FDL "offer a more robust conception of how instructional designs can be created"? How can you include FDL in your personal design practice? How can it help you create more complete, coherent, and effective designs?

For Further Thought

As part of this activity, you may also want to carry out some thought experiments such as:

1. What would happen to the overall design if you changed the function performed by one of the layers you identified? Speculate on how the design might be more or less effective by making a change.
2. How do the functions within each layer work together to contribute towards a whole? Can you find any elements you (or the designer) did to make the connections between layers work better, or somehow be more meaningful?

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At BYU, Dr. McDonald has taught courses in instructional design, using stories for learning purposes, project management, learning theory, and design theory. His work can be found at his website: http://jkmcdonald.com/