Athabasca University Master of Arts - Integrated Studies

# AN INTERDISCIPLINARY DESIGN FRAMEWORK

By

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## Abstract

This paper explores the concept of design as a universal and multidisciplinary process. A case is made that a broad range of disciplines including research, systems engineering, teaching, and project management share many design-related processes and instruments. In addition, while existing design frameworks may exist there is no industry-sanctioned model or universally accepted approach to address multidisciplinary design problems. This paper illustrates how design-related elements from different disciplines can be synthesized into a hybrid interdisciplinary design framework for potential universal adoption. This framework could benefit and unite novice and seasoned design practitioners from a broad range of fields and function as catalyst for the creation of a supporting community and body of knowledge.

## INTRODUCTION

I am a designer, a systems thinker, and a lifelong learner. As a design practitioner I have participated in and observed the process of design from multiple perspectives over the last twenty years. My formal undergraduate education in design was guided primarily by a positivist doctrine that stressed laying a foundation for learning based on the design science and theory. While I was taught some practical design skills (e.g., typography, layout) I was not taught an industry-sanctioned model to follow, but rather a few suggested guidelines for best design practice. I was released into the world with an understanding that I would discover how to effectively resolve and manage design projects through my own experiences and practice. While I support Driscoll's (2005) notion "that knowledge is constructed by learners as they attempt to make sense of their experiences" (p. 387), over the years I have discovered the weaknesses in relying solely on personal experience to guide design practice. I have also discovered that I am not alone in the observation that design lacks a universal and systematic approach. As Cross (2007) reinforces "most design in practice still appears to proceed in a rather *ad-hoc* and unsystematic way. Many designers remain wary of systematic procedures that, in general, still have to prove their value in design practice" (p. 109).

I concur with Cross that a prevailing approach to design has yet to emerge and establish itself as the norm, however, I would also posit that some existing design frameworks possess demonstrable value. Furthermore, over the years I have learned that design is a creative and multidisciplinary process that traverses and connects a broad range of knowledge areas. Through my interdisciplinary studies and my experience in both designing and managing design projects I have discovered instruments, processes, and frameworks within other disciplines that also possess elements of value to design practitioners, in particular, the disciplines of research, systems engineering, teaching, and project management, Through an analysis of these interrelated knowledge areas I have gained insight into how to integrate these elements into a hybrid interdisciplinary design framework.

The underlying principle behind this framework is that the design process is multidisciplinary in nature and design knowledge and practice and can be optimized by blending elements from different disciplines into a systematic approach that acknowledges the social context in which it is situated. By adhering to this methodical and participatory approach multidisciplinary practitioners can channel their creative insights into successful solutions, manage the design process more effectively, and facilitate the development of individual and collective design knowledge.

This framework also reflects the notion that design problems or opportunities are often hard to define and subject to evolving forces and constraints imposed by a design project's environment. This means that a perfect solution can never be achieved; rather an optimal solution must be negotiated and managed within these contexts. This negotiation does not mean that creativity and iterative exploration is stifled, by applying a participatory, systematic, and multidisciplinary approach a balance can be struck between innovation and control.

It is my intention to show that that existing frameworks have failed to strike these balances effectively. However, by synthesizing elements from disciplines possessing design-related attributes an interdisciplinary design framework can take shape. This design framework can not only guide and teach individual practitioners but also serve as a foundation to build a community of multidisciplinary practitioners who can collectively aggregate their experiences into a supporting body of knowledge. The boundaries of the design discipline should be treated as permeable and always subject to question for “a discipline’s boundaries are ultimately defined by the actions of its practitioners” (Palys, 2003, p. 33).

Part 1 of this paper explores the discipline of design, what constitutes design ability, and what I perceive to be valued elements within other disciplines that can inform the creation of an interdisciplinary design framework. Part 2 proposes a potential structure for the framework with inherent life cycle phases, processes, and instruments that interdisciplinary practitioners can employ. Part 3 of the manuscript provides a sample of how aspects of the proposed framework can be applied in practice.

## PART 1: TOWARDS AN INTERDISCIPLINARY DESIGN FRAMEWORK

### *The Discipline of Design*

While efforts have been made to formalize design practice within particular design-related disciplines an overall universal approach applicable to all design problems or opportunities is lacking. This may be because “the discipline of design is still quite young, and still has a relatively small research base” (Cross, 2007, p. 14). However, this has not deterred newer disciplines from formally establishing unified bodies of knowledge with accompanying standard frameworks for application, for example, the Software Engineering Body of Knowledge (SWEBOK) or the Project Management Body of Knowledge (PMBOK). Perhaps it could be argued that disciplines such as these are more “technical” in nature and their positivist roots facilitate a systematic approach to encapsulating and applying knowledge. That is, their practice follows a deductive tact to problem solving that validates assumptions based on quantitative and measureable outcomes derived from a depersonalized and systematic approach to the problem situation.

Yet, design shares the same positivist origins and despite recent challenges to this doctrine (Schön, 2007) has there not been ample time to aggregate knowledge and construct a standardized framework? Would not both novice and expert design practitioners and society at large benefit from collaborating in the construction of a framework applicable to all design problems or opportunities? This framework would provide individuals from any background and within any context with the structure and tools to undertake a design problem. I suggest that innovation and knowledge is generated from exploration, experimentation, substantiation, and assimilation and these processes are integral to the process of design. Yet why haven't design practitioners made a concerted effort to explore and integrate design knowledge into a common body and approach?

I suggest that the breakdown is because design problems have been seen as isolated and discipline-specific issues bound to a particular application area. The focus of improving design practice has been bound to the perceived discernable differences of the end-artifacts produced by each discipline, not the similarities in the design process itself that led to their realization. Moreover, that due to the interdisciplinary nature of design its processes have been integrated into a broad range of disciplines. This has resulted in a blurring of the lines of what should, or should not be, aggregated into a common body of knowledge and a universal approach. This condition should be seen as constructive for it gives rise to the opportunity for interdisciplinary cross-pollination. That is, it allows other disciplines to question and investigate how design-related knowledge from other fields can inform the evolution of their own discipline, or be aggregated to form a holistic body of knowledge for universal benefit.

I propose that design problems are not unique or bound by disciplinary boundaries but are homogeneous in nature. That design is a system of interrelated processes elicited in response to a need to deconstruct an ill-defined problem and construct a creative artifact appropriate to resolve the problem context. The design system and process is instigated by the need to create an artifact based on a new problem or opportunity arising within the environment, or in response to a required adaptation to an existing artifact within the system. Creativity is achieved by devising an aesthetic and functional solution that successfully resolves the needs of all project stakeholders while working within the constraints imposed by the project. Yet despite the lack of a universal approach to design some frameworks exist within the discipline possessing characteristics of value in establishing an interdisciplinary design framework.

*User-Centered Design (UCD)*

Unlike the positivist approach that suggests “the route to objectivity requires investigators to depersonalize the research situation” (Palys, 2003, p. 7) UCD embraces the constructivist approach, that is, that a user’s/customer’s values, beliefs, experiences, culture, and knowledge are an integral part of the design process. These human elements must be deconstructed and accounted for in order to create an effective solution that will be adopted by these users. This consideration is important given the emergence of the Net and the globalization of our society. This has resulted in a cultural melting pot with team members and customers interacting with each other across diverse geographic and sociocultural contexts. In addition, the artifacts created in one context now often transcend their original context and geographic locale (del Galdo and Nielson, 1996, p. 75). An overview of the UCD framework is provided in Table 1.

While the origins of UCD stem from architecture Vredenburg and his team (2002) optimized the approach for designing human information systems and within this user-centered approach are elements of value in establishing an interdisciplinary design framework. In UCD design requirements and solutions are derived based on ongoing and direct interactions with the end-users of the required artifact.

Table 1. *The User-Centered Design (UCD) Framework*. Table 1 was created from an analysis of the book *User-centered Design: An Integrated Approach* (Vredenburg et al, 2002). A short descriptive block provides an overview of the four key phases of the approach followed by some of the key processes inherent within each of these phases. The overall focus of the approach is on understanding the requirements of users, the functions of the proposed design object, and the needs of the target market. Through participatory development activities design solutions evolve iteratively based on user feedback and evaluation against defined requirements. Feedback is attained even after the project has been released into the market to inform future designs and development activities.

Table 1: ***The User-Centered Design (UCD) Framework***

| **Phases** | | | |
|---|---|---|---|
| **Planning** | **Concept** | **Detailed design and development** | **Life-cycle management** |
| This phase is focused on requirements gathering. “Functional requirements specify what the product must do. User requirements specify what the users want the product to do” (Vredenburg et al, 2002, p. 111). The proposed design is assessed against the current market and how the design aligns with the sponsoring entity’s portfolio. Sample target users are solicited for data collection and a basic plan is formulated. | “The culmination of the conceptual design phase is the high-level design of everything the customer sees, hears, and touches” (Vredenburg et al, 2002, p. 122). Use-cases and user-profiles are established outlining tasks, customer types, and motivations for use. Target customers assess the current competitor’s solution and data is collected to inform usability and acceptance criteria (e.g., time on task, number of errors, customer satisfaction). A low-fidelity prototype of the design is created and presented to customers to attain conceptual feedback and confirm the validity of usability objectives. | “Prototyping is used to arrive at a high-level design of all aspects of the total customer experience” (Vredenburg et al, 2002, p. 151). Customers assess prototypes of the design via usability testing techniques. Feedback is assessed against usability benchmarks and the prototype is updated to address needs and problems. The design is continually perfected until usability criteria have been satisfied. A prerelease of the final offering is provided to sample customers for real-world assessment. Feedback attained informs future iterations of the solution. | “Even after the product is released, UCD is employed to ensure the product has met its objectives and will meet the needs of its intended customers” (Vredenburg et al, 2002, p. 163). Customer satisfaction data is collected via satisfaction surveys. A benchmark assessment may be performed by comparing the chief competitor’s offering with the final proposed solution. Key members of the project team review benchmark and customer satisfaction data to determine how the process and product can be improved in the future. |
| **Inherent Phase Processes** | | | |
| • Describe market and audience<br>• Logistical planning<br>• Requirements gathering and prioritization<br>• Sizing and scheduling<br>• Create UCD plan<br>• Competitive evaluation. | • Task analysis<br>• Use cases<br>• Contextual inquiry<br>• User profiles<br>• Low-fidelity prototyping<br>• Design walkthrough | • Medium and high-fidelity prototyping<br>• Heuristic evaluation<br>• Usability walkthrough<br>• Usability test<br>• Design guideline development<br>• Early-ship survey | • Customer satisfaction survey<br>• Benchmark assessment<br>• Postmortem evaluation |

The UCD framework is based on a philosophy of participatory design and incorporates sub-processes and instruments to ensure representation and engagement amongst customers and members of the design team. “The concept of user-centered design is very simple: Every step of the way, take the user into account as you develop your products” (Garrett, 2003, p. 19). This user-centered approach is becoming increasingly important as “there is a growing recognition that design focused on providing superior experience and value for users is instrumental for business success” (Boztepe, 2007, p. 514). It is not surprising therefore as Boztepe suggests, that “an increasing number of global corporations are now employing user-centered design teams to develop products that better fit users’ requirements in different localities” (p. 514).

The UCD framework employs a number of interdisciplinary instruments and sub-processes that could be utilized in formulating an interdisciplinary design framework. A summary of these elements has been identified in Table 2. Some of the key sub-processes include: requirements gathering, logistics planning, competitive analysis, iterative design and feedback cycles, and post-project evaluation. Instruments include: work breakdown structures (WBS), user profiles, use-cases, prototypes, and focus groups.

The framework is not without its shortcomings. UCD does not incorporate a change management process to ensure designs do not deviate too far from their original plan or scope. This is because the framework supports a philosophy that sees change as a positive and necessary force and exploration and experimentation is encouraged as feedback is received from users. Control is perceived as a negative force that stifles creativity and the autonomy of creators. The framework also does not possess risk management processes; therefore, risk identification and mitigation strategies are not formally devised. The lack of these elements means design projects are subject to resource overruns and vulnerable to risks that may arise during the design process.

The primary criterion for a successful design in UCD is based on how well the final solution meets the needs and expectations of its users. Acceptance is perceived to translate into a quantitative return on investment. This viewpoint, however, is problematic from a business perspective, as a project cannot be deemed successful solely on the merits of customer satisfaction. For example, “meeting customer requirements by overworking the project team may produce negative consequences” (PMI, 2004, p. 180) and the degree of effort required to realize a project must be economically feasible.

In summary UCD has an important value, i.e. design is a participatory and iterative process. The framework is sensitive to the cultural attributes (e.g., beliefs, motivators, attitudes) that people bring into the design context and has developed processes and instruments to capture, assess, and compensate for these factors. The framework recognizes that what you expect people to do and what they actually do are very often two different things, and “you can only really know how good or bad the design is by using it” (Cato, 2001, p. 13).

Table 2. *Interdisciplinary Design Elements From the User-Centered Design (UCD) Framework*. Table 2 was created from an analysis of *User-centered Design: An*

*Integrated Approach* (Vredenburg et al, 2002). The table highlights instruments and sub-processes from each of the framework's phases that can be applied to address interdisciplinary design problems or opportunities. These elements provide insight into how to integrate aspects of a user-centered and iterative development approach into the construct of an interdisciplinary design framework.

Table 2: ***Interdisciplinary Design Elements from the User-Centered Design (UCD) Framework***

<table>
<tr><th colspan="4">User-Centered Design Framework Phases</th></tr>
<tr><th>Planning</th><th>Concept</th><th>Detailed design and development</th><th>Life-cycle management</th></tr>
<tr><th colspan="4">Key Interdisciplinary Design Framework Instruments</th></tr>
<tr><td>• Design plan<br>• WBS<br>• Schedule<br>• User class and sample definitions<br>• Usability specification<br>• Participants list<br>• Specialized expertise required beyond core team<br>• Competitive study<br>• Design notebook</td><td>• Interactive participant instruments (e.g., focus groups)<br>• Surveys and questionnaires<br>• User profiles<br>• Use cases/scenarios<br>• Usability matrices<br>• Usability tests<br>• Low-fidelity prototypes</td><td>• Medium and high-fidelity prototypes<br>• Usability tests</td><td>• Customer satisfaction survey<br>• Postmortem project report</td></tr>
<tr><th colspan="4">Key Interdisciplinary Design Framework Sub-Processes</th></tr>
<tr><td>• Functional and user requirements gathering<br>• Work planning<br>• Competitive analysis</td><td>• Recruitment of participants based on sample<br>• Team formulation<br>• Usability testing<br>• Iterative design cycle</td><td>• Data collection<br>• Data analysis<br>• Usability testing<br>• Iterative design cycle</td><td>• Final product evaluation<br>• Final project review</td></tr>
</table>

*The Design Context*

Design and art share many similarities, however, I suggest that design binds a greater aesthetic appreciation to equally achieving both form and function in the man-made artifacts (e.g., products, systems, services, results) it creates. Moreover, that in design external forces (e.g., users, markets, sponsors, budgets, timelines) impose specific requirements and constraints that challenge the range of solutions that can be creatively explored and constructed (the solution space). A designer's intrinsic motivation, therefore, comes from creating an artifact that satisfies the functions dictated by these limiters in a highly appropriate, usable, and pleasing form. In essence they achieve a successful "'bridging' between a problem space and a solution space "(Cross, 2007, p. 13).

An important constraint within the design context is time, for unlike some disciplines the nature of the problem does not allow creative explorations to continue in perpetuity. As Cross (2007) suggests "the designer is constrained to produce a practicable result within a specific time limit, whereas the scientist and scholar are both able, and often required, to suspend their judgments and decisions until more is known" (p. 23). Limiters are important drivers for design process as a design problem without requirements or constraints means there is no definitive problem to resolve or barriers to limit the scope or direction of the exploration. An interdisciplinary design framework, therefore, should establish a sense of urgency that can be channeled through a systematic and controlled approach to problem structuring and solving.

Some experts (Checkland 1981; Cross 2007; Schön 1987) suggest that the nature of a design problem is often ill-defined or "messy." In essence, "the situation is complex and uncertain, and there is a problem in finding the problem" (Schön, p. 129). Furthermore, design problems "are not problems for which all the necessary information is, or ever can be, available to the problem-solver. They are therefore not susceptible to exhaustive analysis, and there can never be a guarantee that 'correct' solutions can be found for them" (Cross, 2007, p. 24).

The ambiguous nature and complexity of design problems means that designers face challenges in uncovering the source of the problem. They must use both qualitative and quantitative instruments to formulate a holistic understanding of the problem situation while working within constraints. Once an approximate understanding of the situation is realized they must translate it into objectives and parameters that guide formulation of the solution space. This understanding is validated and refined through cycles of feedback, reflection, and re-design. Schön (1987) refers to this as "reflection-in-action", whereby a designer engages in a conversation with the problem situation, reflects on the situation's back-talk, reframes the problem, and implements a strategic action in response (p. 79).

Design solutions in this light can never be perfected, as there are too many "unknowns"; therefore no absolute truth or answer can be found. A designer can only approximate the best solution while working within the constraints of the problem situation. These approximations, however, can be refined to a high degree by utilizing two agents: (1) by adhering to a systematic design framework that ensures a holistic understanding of the problem and provides designers with a set of instruments to effectively resolve design problems, and (2) by designers applying, sharing, and developing their knowledge while tackling a diverse range of problems with different constraints and within different contexts. In other words, a design practitioner is not an artist but they can still be a artisan by skillfully employing a creative and systematic approach to resolving a design problem. Their artistry is linked to their repertoire, that is, their ability to draw on their past experiences to tackle unfamiliar design problems (Schön, 1987, p. 140).

*Design and Project Management*

An interdisciplinary design framework would benefit from integrating processes and instruments from the project management framework. Existing design frameworks (e.g., UCD) focus on design and production-related processes, not management processes. Management processes, however, are important as they link a framework's processes together and ensure the overall integrity of a design project.

Designers and project managers both organize their work in terms of projects. All design projects must be managed to some degree to ensure the design process is in keeping with project parameters and is progressing towards an appropriate solution space. In addition, Schön (1987) suggests that there are often ambiguous zones of discretionary freedom in a design project, especially between the sponsoring entity and the designer (p. 292). These are not design problems per say but "people problems" and warrant that a different set of skills and instruments should come into play. An interdisciplinary design framework, therefore, should incorporate include someone with project management expertise in the multidisciplinary team and incorporate management processes to guide the project as a whole.

The traditional framework for project management in North America is derived from the Project Management Body of Knowledge (PMBOK) formulated by the Project Management Institute (PMI). It is recognized that PMBOK “is not the only way of structuring the project management knowledge and process but it is one of the more common approaches” (Pons, 2008, p. 84). The PMBOK framework utilizes a standard set of processes (e.g., initiating, planning, executing, monitoring and controlling, closing) to manage projects. See Table 3 for an overview of the framework’s phases and inherent processes.

The PMBOK framework does not embed design-related processes in its default framework. Rather the framework suggests that “each application area generally has a set of accepted standards and practices” (PMI, 2004, p. 13) and industry common practices will often dictate the preferred life or product cycle within a particular industry. This gap means project managers seeking guidance in design-related activities must consult additional external frameworks to inform practice. In addition, as the discipline of design lacks a standardized body of knowledge designers seeking guidance in project management activities must look to frameworks like PMBOK.

Table 3. *The Project Management (PMBOK) Framework*. Table 3 was created from an analysis of the manual *A Guide to the Project Management Body of Knowledge* (Project Management Institute, 2004). Key processes inherent in the framework’s five overarching phases are identified and brief descriptions are provided. The overall focus

of the framework is on pre-defining all requirements and plans at the onset of a project and then monitoring and controlling changes or risks that jeopardize its delivery on time and within budget. The framework follows a linear approach to development that terminates with the delivery of the defined deliverables and does not solicit ongoing feedback beyond closing of the project.

Table 3: ***The Project Management (PMBOK) Framework***

| **Phases** | | | | |
|---|---|---|---|---|
| **Initiating** | **Planning** | **Executing** | **Monitoring & controlling** | **Closing** |
| Business needs are defined before initiation activities commence. Initiation "starts a project or project phase, and the output defines the project's purpose, identifies objectives, and authorizes the project manager to start the project" (PMI, 2004, p. 43). Customers and stakeholders are involved at the onset of a project in an effort to improve shared ownership and acceptance. | The planning process places "emphasis on exploring all aspects of the scope, technology, risks, and costs" (PMI, 2004, p. 46). The project manager involves project stakeholders in formulating a project plan. The plan is comprised of a set of subsidiary plans defining the scope, costs, and risks and how it will be executed, monitored, and controlled. The plan is seen as a living document that is updated as the project progresses. | Executing "involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project management plan" (PMI, 2004, p. 55). Activities include: acquiring and orienting the project team and external contractors, managing work, performing quality assurance, and ensuring stakeholders are kept informed, | Monitoring and controlling ensures "that project performance is observed and measured regularly to identify variances from the project management plan" (PMI, 2004, p. 59). If warranted, deviations in scope, quality, schedule, or cost can trigger the change control process. | Project closing is "used to formally terminate all activities of a project or a project phase, hand off the completed product to others or close a cancelled project" (PMI, 2004, p. 66). |

| Inherent Phase Processes | | | | |
|---|---|---|---|---|
| • Develop project charter<br>• Develop preliminary scope statement | • Develop project plan<br>• Scope planning<br>• Scope definition<br>• Create WBS<br>• Activity definition<br>• Activity sequencing<br>• Activity resource estimating<br>• Activity duration estimating<br>• Schedule development<br>• Cost estimating<br>• Cost budgeting<br>• Quality planning<br>• Human resource planning<br>• Communications planning<br>• Risk management<br>• Risk identification<br>• Qualitative risk analysis<br>• Quantitative risk analysis<br>• Risk response planning<br>• Plan purchases and acquisitions<br>• Plan contracting | • Direct and manage project execution<br>• Perform quality assurance<br>• Acquire project team<br>• Information distribution<br>• Request seller responses | • Monitor and control project work<br>• Integrated change control<br>• Schedule control<br>• Cost control<br>• Perform quality control<br>• Manage project team<br>• Performance reporting<br>• Risk monitoring and control<br>• Contract administration | • Close project<br>• Contract closure |

These shortcomings reveal the latent need for emergence of an integrated interdisciplinary framework for both design and management practitioners. Design and project management frameworks are well suited for aggregation as they both share an awareness of the constraints imposed within a project's context and that solutions must be negotiated within the restrictions imposed by their contexts.

The PMBOK framework is quantitative in nature and its roots stem from the evolution of business administration and a positivist tradition. Based on a business need or opportunity the framework focuses on investigation and data collection at the onset of a project. These needs formulate a project baseline from which activities are executed in a progressive order and rigourously monitored for change. Deviations from the predefined route are seen as a negative force that must be controlled to ensure the project is delivered on schedule, and within budget. The strengths of this framework relate to the processes and instruments it utilizes to ensure a project is economically viable; controlling project constraints (e.g., scope, time, cost, quality), and identifying and managing risks that may jeopardize the project. Table 4 outlines the key instruments and processes that can be distilled from the framework of merit in forging an interdisciplinary design framework.

Part of the weakness of the PMBOK framework resides in its adoption of a paradigm that envisions design and project management as unique and unrelated disciplines. In addition, PMBOK fails to recognize the commonalities between design-related fields; therefore, it has consciously segregated design-related processes from its framework.

The framework envisions a project as “a temporary endeavor undertaken to create a unique product, service, or result” (PMI, 2004, p. 5) and “the purpose of a project is to attain its objective then terminate” (p. 7). An interdisciplinary design framework, however, should acknowledge that while designing cannot continue on in perpetuity that the nature of design is iterative and ongoing. A design framework, therefore, should be cyclic, not linear, with continuing processes that continually seek feedback to inform subsequent activities even after an artifact is created. Whether or not to pursue these endeavors is a business decision, however, the framework should solicit and manage this knowledge as long as the artifact is being actively used.

The PMBOK framework emphasizes that a project's path and barriers can be primarily defined at the start of a project and then opposing conditions mitigated to successfully stay the predefined course. While the framework recognizes that "projects seldom run exactly according to the project management plan" (PMI, 2004, p. 96), and that plans can be updated accordingly, I posit that this perceived flexibility is overshadowed by its rigidity, i.e. the imperative to control change.

While change control and monitoring processes may help streamline projects they may also limit creativity and serendipity. Rigidity and control does not allow sufficient time for creative midstream explorations, incubation, or validation of solutions through ongoing participatory design and a better balance must be struck between control, creativity, and responsiveness.

Table 4. *Interdisciplinary Design Elements From the Project Management Framework*. Table 4 was created from an analysis of *A Guide to the Project Management Body of Knowledge* (Project Management Institute, 2004). The table highlights instruments and sub-processes from each of the framework's phases that can be applied to address interdisciplinary design problems or opportunities. These elements provide insight into how to integrate change control, risk management, performance monitoring, and other management processes into the construct of an interdisciplinary design framework.

Table 4: ***Interdisciplinary Design Elements from the Project Management Framework***

| **Project Management Framework Phases** | | | | |
|---|---|---|---|---|
| **Initiating** | **Planning** | **Executing** | **Monitoring & controlling** | **Closing** |
| **Key Interdisciplinary Design Framework Instruments** | | | | |
| • Preliminary scope statement<br>• Project charter | • Project plan<br>• Cost management plan (budget)<br>• Communications plan<br>• Procurement plan (statement of work)<br>• Scope statement (requirements, boundaries, acceptance criteria, constraints, assumptions)<br>• Risk management plan (register, contingency plans)<br>• Schedule (network diagrams, milestone list, Gantt)<br>• Activity list (work breakdown structure)<br>• Resource breakdown structure (RAM)<br>• Quality planning (quality metrics, cost-benefit analysis)<br>• Stakeholder analysis | • Performance reports<br>• Rewards | • Change requests | • Lessons learned document<br>• Acceptance document |

| Key Interdisciplinary Design Framework Sub-Processes | | | | |
|---|---|---|---|---|
| • Environmental scanning | • Risk planning<br>• Scope planning<br>• Cost planning<br>• Communication planning<br>• Logistical planning (time, resources, activities)<br>• Quality planning | • Performance management | • Change management | • Administrative closure |

*Design Abilities*

"A designer makes things. Sometimes he makes the final product; more often, he makes a representation—a plan, program, or image—of an artifact to be constructed by others" (Schön*,* 1987, p. 78). Schön suggests we have been mistakenly been following the traditional doctrine of technical rationality that advises that research creates theory which in turn should guide practice. Schön posits, however, that practitioners learn by applying and developing their skills in practice and in their actions they uncover phenomena that can guide theory creation. This suggests that we should recognize that knowledge is created in the informal learning that occurs while a designer makes things as part of their practice. More importantly we must identify and foster the skills design practitioners employ in their making to inform their practice and the discipline's evolution. An interdisciplinary design framework can facilitate this by utilizing instruments and processes that call these skills into action and augment their potency.

Cross (2007) suggests that design is not an exclusive activity but something that all people can do, however, like other skills it is more prominent in some individuals (p.

49). Cross identifies four core design abilities, which are the ability to 1) resolve ill-defined problems, 2) adopt solution-focusing strategies, 3) employ abductive/productive/appositional thinking, and 4) use non-verbal, graphic/spatial modeling media (p. 38). I agree that each of these skills has merit but believe this list can be further elaborated.

Ultimately a designer is a professional communicator. As Cross suggests designers often possess skills in utilizing non-verbal media to communicate, however, they must also possess and utilize strong verbal and interpersonal skills throughout a design project. The continuing and open flow of information is vital to inform the design process and the designer is required to interact effectively with various stakeholders and establish the necessary communication channels. For example, the ability to capture and present concepts, engage in dialogue with stakeholders to understand their needs, and participate in team design critiques.

A designer must also possess the ability to see the project objectively from various viewpoints. Well it could be argued that attaining absolute objectivity is not possible a designer must possess the ability to periodically “step into another person’s shoes” so they can analyze the problem situation from the unique perspective of each stakeholder. In addition, designers must also be able to assume a macro-micro viewpoint of the project at any given point in time. This means the ability to step back and view the project from a holistic perspective and the interrelations of its parts (macro) or look at the specific details inherent in the specific task at hand (micro). For example, understanding how a design solution will be a benefit or a detriment to different parties, or identifying and ordering all the required work activities to establish priorities and dependencies. This parallels what Remington and Pollack (2008) suggest being an important ability for project managers when dealing with complex projects. That is, being able to change between the perspectives of an eagle and mouse in order to analyze a project from different levels.

A designer also possess the ability to deconstruct complex problem situations, identify relationships between the various elements, and reconstruct or conceptualize potential solutions based on feedback, reflection, and requirements. As Schön (1987) suggests “his artistry is evident in his selective management of large amounts of information, his ability to spin out long lines of invention and inference, and his capacity to hold several ways of looking at things at once without disrupting the flow of inquiry” (p. 130).

Effective conceptualization and construction of a design artifact requires knowledge of the inherent properties of the materials or media to be used in its making. These media may vary by application area along with rules that govern their use. Designers may possess generic problem solving abilities, however, each application area may have domain-specific knowledge that must be used to inform the design process. A designer attains this knowledge by designing within these contexts. For example, a web designer must be familiar with the properties and limitations of mark-up languages (e.g., HTML) and web rules and standards (e.g., accessibility, security). Whereas an architect must know the characteristics of different building materials (e.g., structural integrity, transparency, weight) and the pertinent by-laws and building codes that guide their use. An understanding of the media and its conventions is critical to their craft.

One of the skills a designer possesses is the ability to transfer this media and domain-specific knowledge into different contexts and application areas. In doing so they can create new and innovative artifacts. As Cross (2007) suggests designers are well versed in the language of material culture “and draw upon it as the primary source of their thinking. Designers have the ability both to ‘read’ and ‘’write’ in this culture: they understand what messages objects communicate, and they can create new objects which embody new messages” (p. 26). For example, an industrial designer creating a new e-reader who possesses a background in traditional book design may employ this prior knowledge in the artifacts creation.

All these proposed design abilities are skills. “A skill is the ability to do something well, developed through knowledge and practice” (Watson and Tharp, 2008, p. 3). Skills can be taught or learned through self-directive behaviours (e.g., practice) and an interdisciplinary design framework can reinforce learning and practice by utilizing processes and instruments that call these design-related skills into play.

In summary, the process of design is constraints based and the most appropriate solution must be negotiated within the limitations imposed by the project context. By employing a systematic framework that embodies important design sub processes (e.g., deconstruction, analysis, feedback, reflection, conceptualization) design practitioners of all levels can more efficiently organize and control their efforts without sacrificing creativity. Using instruments embedded within the framework that facilitate the development of important design-related skills can foster design knowledge and expertise. Practitioners can further increase their design knowledge and abilities by mastering an understanding of the media inherent in different design application areas and applying these to different problem situations.

*Design and Learning*

An interdisciplinary design framework should be seen as a system supported by a corresponding body of knowledge and a community of practitioners from a diverse range of application areas. Wenger (2002) suggests that communities of practice share three common structural elements: domain, community, and practice. The domain establishes a collective identity oriented around a specific area of knowledge. The community facilitates mutual interaction and relationship development amongst its members, and the practice is the content and resources that the community collectively develops (p. 27-29). In this regard a community of interdisciplinary design practitioners (the community and domain) can collectively share and contribute to a body of knowledge and the framework (the practice).

According to Banathy (1992) one of the key processes of a system is its ability to adapt based on feedback it receives from within the system or from its environment (p. 103). A key source of this feedback is the community of practitioners who utilize the framework to resolve real-life problems. This feedback contributes to the supporting body of knowledge and guide’s the framework’s design. Feedback is not just important to the evolution of the interdisciplinary design framework itself, the practitioners who utilize the framework also require feedback to adapt their practice and learn. The framework in this sense functions as a learning system. It must draw on the interactions and feedback of its users to improve itself, but it must also facilitate feedback and development of design-related knowledge and expertise amongst its users. But what exactly is expertise and how can a framework foster its development?

Driscoll (2005) proposes “in order to solve any problem, learners must determine what variables are relevant, what information should be sought about those variables, and, when the information is obtained, what should be done with it” (p. 235). Experts differ from novices because they have learned how to automatically recognize patterns and problem types and draw on their existing experiences and knowledge to organize solution structures. In addition, when experts confront a problem they also question whether or not their existing knowledge is relevant to the particular situation at hand. If not, they embark in exploration and self-learning activities to inform their approach (Bransford et al, 2000, p. 44-50).

In my view, therefore, expert designers are lifelong and adaptive learners who possess a diverse repertoire of knowledge that they can potentially apply to different design problems, but, importantly, before instigating solutions their experience encourages them to think before they act. This practice parallels Schön’s (1987) observation that in “a good process of design, this conversation with the situation is reflective. In answer to the situation’s back-talk, the designer reflects-in-action on the construction of the problem, the strategies of action, or the model of the phenomena, which have been implicit in his moves” (p. 79).

This idea of reflection before action is further strengthened by Cato (2001) who states, you “cannot just jump in to creating a design; you have to give a reasonable and appropriate amount of time to discovery (saturation and incubation) stages if you are going to come up with quality insights” (p. 11). These observations suggest, therefore, that time for incubation and reflection should be incorporated into an interdisciplinary design framework.

Feedback, reflection, and exploration are important learning processes and an expert designer should not solely internalize his/her thoughts and proposed actions but share these with others. This sharing can take the form of contributions to the body of knowledge, working collectively as part of team, or purposely coaching novice practitioners. Schön (2007) suggests that coaching is the best form of teaching as design knowledge is primarily tacit. Through demonstration, questioning of a novices work, and engaging in a dialogue of reciprocal reflection-in-action, an expert can play an important coaching role (p. 38; 303). Furthermore, Keller (1987) suggests that if learning is to be optimized, learners (novices) must be able to relate knowledge to their personal goals and see the relevance of its application (in Driscoll p. 324-334). This evidence suggests that novices would learn best by resolving real-life design problems while being supported by expert practitioners. The most appropriate setting for these interactions is the design studio as “design studios are premised on a particular kind of learning by doing” (Schön, 2007, p. 117).

The optimal design studio in an interdisciplinary design framework is supported by a multidisciplinary design team comprised of experts from a broad range of disciplines (e.g., research specialist, marketing specialist, technical lead, design lead, project lead). While a specialized expert may be solicited for specific project requirements the multidisciplinary design team works collectively on a design problem throughout the design process. This approach provides learning opportunities for experts and novices alike as they are exposed to a myriad of ideas and feedback from different perspectives. This learning can be further facilitated by team participation in group-oriented activities (e.g., brainstorming solutions, team critique of concepts). The interactions and discoveries of studio activities, however, should not be trusted to individual or collective memory. They must be captured in an instrument that can guide subsequent design activities and inform overall practice. The project notebook is an ideal tool to accomplish this task.

A project notebook should be created for each design project to facilitate communication and learning while serving as a formal project record. All team members should have access to the notebook and contribute to its development. The project notebook should include items such as: a list of activities (e.g., work breakdown structure), activity and project timelines (e.g., Gantt), roles and responsibilities (e.g., RACI), a lexicon, meeting minutes, project data (e.g. research findings, requirements), concepts and feedback, and project-related documents. While the project notebook could be paper-based information and communication technologies and the Internet (Net) offer a variety of vehicles that can serve this purpose well.

The Net also means design studios are no longer bound to specific physical spaces. Networks enable team members to collaborate, share knowledge, and learn collectively from diverse geographic locals. Social networks on the Net (e.g., Facebook) and the success of Open Source software demonstrate that social networks can encourage the development of collaborative communities of practice and/or collective identities. These virtual spaces are well suited to facilitating the development of a body of knowledge and a learning community based on an interdisciplinary design framework. In many cases these virtual spaces can be created for free or at a relatively low cost and are highly scalable and accessible for those privileged with access to the Net. These social spaces can be a valuable resource to solicit feedback on a preliminary set of designs, seek advice, attain industry or application-specific information or standards, recruit specialized expertise, or propose a collective design project or research inquiry.

Virtual or corporeal, interdisciplinary design studios can be optimized for learning and design through the process of narrowing. Narrowing involves strengthening a desired behaviour by controlling the specific setting in which it occurs (Kanfer and Gaelick–Buys, 1991, p. 337). Epstein (1997) describes techniques employed by the famous psychologist B.F. Skinner who utilized a series of narrowing techniques to optimize his environment, for example, by keeping writing aids close by, restricting unrelated activities from occurring in his writing space, and taking measures to shelter himself from disruptions during the writing process (p. 554). Design studios and working spaces can also be optimized in a similar fashion to facilitate learning, designing, and other valued behaviours.

Another important interdisciplinary instrument for developing design knowledge is the personal learning journal. Unlike a project notebook that is created to document and share the collective thoughts and actions of the entire team a personal learning journal is a private account of the design process aimed to facilitate personal learning and practice. As noted, design experts self-regulate their own learning processes and internalize the feedback they receive. Journals are a powerful tool to document experiences and ideas. More importantly, they can provide insight into conditions that lead to emotions of importance to the design process such as creativity. Design skills can be taught through participation and coaching but emotions like creativity cannot, for each individual is inspired under different conditions. These conditions, however, can be documented and serve to inform a program of self-management that fosters creativity and learning. Watson & Tharp (2008) suggest that by recording the events directly preceding (antecedents) and after (consequences) a desired behavour is experienced that a person can gain insight on how to optimize conditions to promote the behavior (p. 68). Schön (1987) has illustrated the importance of designers reflecting on their actions to inform the design process and journals are ideal devices to facilitate this reflection during an active design project or in future situations.

Designers must learn from their experiences as well as those of others but as Palys (2003) suggests, "'knowledge' is not an entity, like gold, that merely awaits our discovery of it" (p. 3). Designers and design teams must actively participate and strive to learn and to teach each other. They accomplish this in part by utilizing an interdisciplinary design framework and contributing to its supporting body of knowledge. They must use this framework and body, however, to explore a design problem and its context in a highly social manner leveraging instruments that encourage verbal and visual interaction. From these interactions designers must construct a solution that addresses the needs of the project but as learners they must also collectively and personally internalize and self regulate their own learning and practice.

*Design and Research*

Designers are researchers for when faced with a problem situation they investigate, deconstruct, reflect, conceptualize, and construct. These processes are akin to those utilized in research design and practice. “Research designs embody and reflect everything from general considerations, such as your priorities and objectives, to very specific decisions regarding who, what, when, where, and how” (Palys, 2003, p. 71). This same statement holds true for designers who oscillate between a macro and micro viewpoint of the design situation.

Kelly (2004) advocates that the key tool used in all research design is the research proposal, suggesting that “presenting the design in a proposal forces researchers to sort out their ideas and make them accessible to others at an early stage” (p. 132). Components suggested include title, background, literature review, aims and objectives, methods, data analysis, ethical issues, dissemination and policy relevance, references and appendices, resources, and a schedule or timetable. Formulation of a proposal-like document (e.g., design brief) should be part of any interdisciplinary design framework as many of these components have direct relevance in formulating logistical plans, justifying design solutions, and contextualizing how the proposed solution relates to existing knowledge and artifacts.

Similar to design practitioners researchers are sensitive to the scope of their inquiry. They attempt to formulate an overarching question that will limit the borders of their exploration and analysis. There is recognition that underlying question will evolve as the research process unfolds. Branley (2004) reinforces “you will keep refining your question for much of your research project as you encounter new ideas, produce new data and have new thoughts. But you need to start somewhere” (p. 147).

The formulation of this foundational question is a valuable instrument in guiding the overall research design process and a beacon to correct actions when practitioners deviate from the objective. Once this nominal question is formulated an operational definition can be created. “Operational definitions represent an effort to articulate the connections between our conceptual variables (theory) and the procedures we use to capture them (data)” (Palys, 2003, p. 62). An interdisciplinary design framework would benefit from incorporating similar devices to aid practitioners in distilling and articulating the problem and in identifying appropriate approaches to attain data and validate designs.

Research design emphasizes the importance of trying to remain objective throughout the research process, and there is acknowledgement, “that the researcher approaches the research from a specific position and this affects the approach taken, the questions asked and the analysis produced” (Byrne, 2004, p. 184). Positivist researchers would argue that objectivity requires isolating measureable facts from the behaviours and beliefs of participants. A designer must be cognizant of their own paradigm and take a neutral stance in facilitating interactions and explorations, as the validity of a design solution must address the needs and perceptions of its users and the contexts of use.

Perhaps the most important contribution research has to offer the design discipline is its philosophy for “researchers tend to work *on* problems not *in* disciplines” (Klein, 2000, p. 13). Moreover this philosophy emphasizes that concepts and solutions must be based on evidence, therefore, it has developed a systematic methodology to accomplish this goal. A comprehensive understanding of the problem may be achieved and appropriate artifacts created by the interdisciplinary design framework adopting elements from research design and combining qualitative and quantitative approaches. In particular, formulating a design brief centered upon foundational statements that define the nature of the problem and the desired end state. These statements shape the scope of the exploration and the formulation of an operational approach to capturing and validated design-related decisions.

*Design and Systems Thinking*

Cross (2007, p. 97) suggests that one of the common aspects design experts appear to share is their ability to be take a broad systems approach to a design problem. I concur with Cross and believe that good designers seem to possess an ability to view a design problem from a holistic perspective. This perspective allows them to deconstruct the problem, identify the elements at work, see the interrelation between these elements, and formulate the best design strategy.

Remington and Pollack (2008) advise that projects are becoming increasingly complex, ambiguous, and subject to constraints. Traditional project management frameworks work when “objectives are clear, fully understood, agreed and relatively stable over time” (p. 3), but are not appropriate in indefinite and complex contexts. They posit that “several authors have recognized that projects are systems and should be addressed systemically” (p. 1), therefore, project managers can benefit by thinking of projects in these terms. I support this view and posit that design projects are indeed systems; therefore, an interdisciplinary design framework should incorporate processes and instruments that facilitate systems thinking and a systemic approach to design. Moreover, an interdisciplinary design framework can be viewed as a system itself, a system that guides the formulation and management of the design projects it engenders. An interdisciplinary design framework should encourage the development of a “systems view”, that is, “a way of looking at ourselves, at the environments we live in, at the systems that surround us, and those we are part of. It is a holistic and expansionist way of viewing the world” (Banathy, 1995a*,* p. 55).

Banathy suggests that you can nurture the development of a systems view by observing and analyzing various types of systems. He proposes using three models or “lenses” to observe and conduct a systems analysis. While these lenses were prescribed by Banathy to aid users in attaining a systems view of educational systems. I suggest, however, that they also hold merit as important instruments in developing a holistic understanding of the design problem, its elements, and the nature of their interrelationships.

The first “systems-environment lens” enables its wearer to see a design project in its context. “It is a lens that projects a ‘bird’s-eye-view’ of the landscape in which the system is embedded" (Banathy, 1995, p. 22). Banathy suggests that systems are nested within other systems; therefore, they possess a characteristic of "embeddedness" (p. 39). Consequently, a design project must not be seen in isolation but as a system nested within other systems. The nature of the relationship between parent-child may influence how a design problem should be approached. Figure 1 illustrates the embeddedness of a design project.

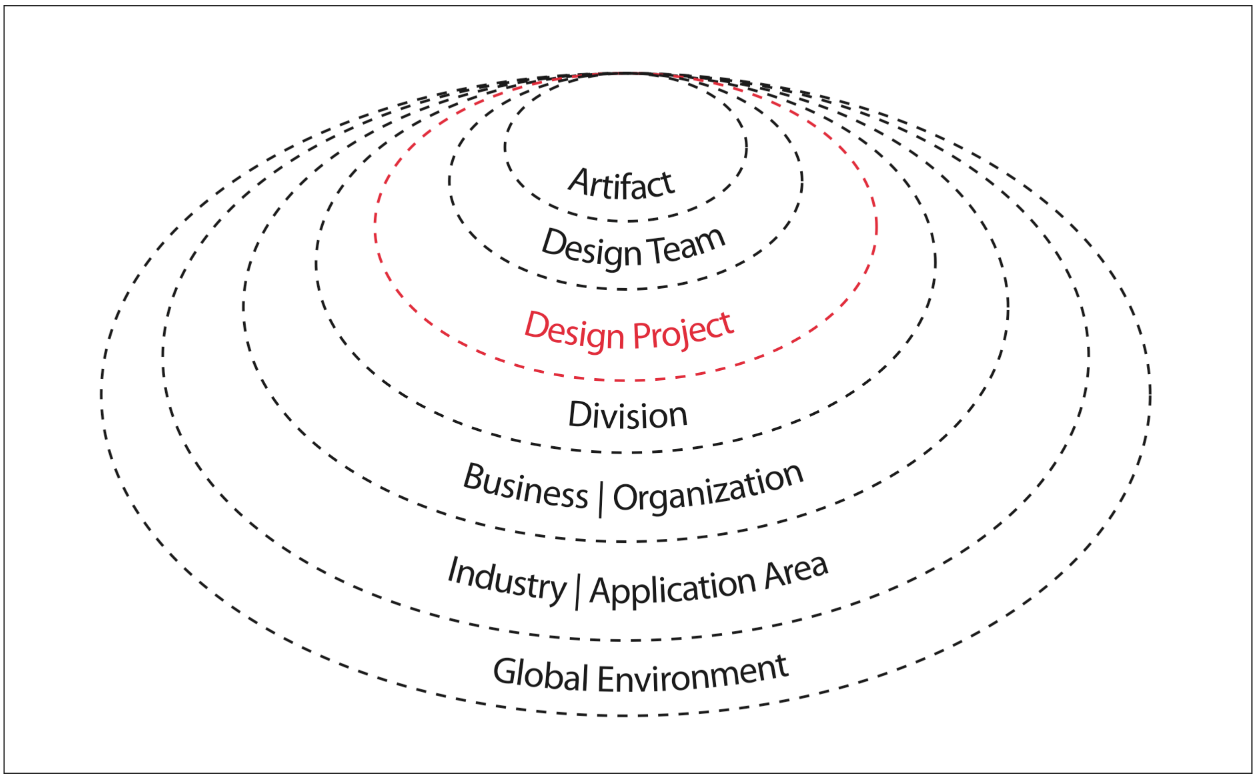



*Figure 1*. The Embeddedness of a Design Project Based on Banathy's Systems-Environment Model. Figure 1 was created based on Banathy's (1992) book *Developing a Systems View of Education*. It illustrates an example of how a design project cannot be perceived as an isolated system but is subject to the forces at work from its surrounding environments.

The "functions-structure lens" captures the goal of the design project, its elements, and their interrelations. It "defines what the system of interest fundamentally does. Using the systems-environment lens as a basis, this lens further refines the system of interest by identifying its purpose, functional model, and components" (Walton, 2004. p. 274).

The third "process lens" reveals the processes at work within the design project. Banathy suggests all processes fall into four categories: input processes, transformation processes, output processes, and system guidance/management processes. Table 5 and Table 6 illustrate how Banathy's functions-structure and process lenses can be utilized to gain insight into a design problem and why they are of value to integrate into an interdisciplinary design framework.

Table 5. *Banathy's Functions-Structure Lens*. Table 5 was created from an analysis of the readings outlined in *Developing a Systems View of Education* (Banathy, 1992). Completion of the table provides multidisciplinary practitioners with an instrument to deconstruct a design problem or opportunity to better understand its structural functions and their interrelations, stakeholder roles and expectations, environmental factors, and project constraints. The use of this instrument combined with other systems thinking techniques facilitates accuracy in the requirements gathering process, project parameters and plans, and formulation of appropriate design strategies.

Table 5: ***Banathy's Functions-Structure Lens***

| Parts | Elements | Sub-elements |
|---|---|---|
| Image | 1). External environment's understanding and expectations of the system? | |
| | 2). Internal stakeholder's understanding and expectations of the system | |
| Definition | 1) Purpose(s) of the system | 1). General purpose |
| | | 2). Specific purpose(s) |
| | 2). System specifications | 1). Clients and services |
| | | 2). Owners of the system |
| | | 3). System's responsibilities |
| | | 4). System-to-system interrelationships |
| | | 5). Constraints |
| | | 6). Inherent worldview(s) |
| Functions | 1). Specific system functions based on the system's purpose and specifications (what it does) | |
| Components | 1). The parts of the system | |
| Structure | 1). The interrelation of a system's components (parts) | |

Table 6. *Banathy's Process Lens*. Table 6 was created from an analysis of the readings outlined in *Developing a Systems View of Education* (Banathy, 1992). The table provides insight into how to identify, differentiate, and categorize processes to inform the resolution of a design problem or opportunity. In addition, it illustrates how systems thinking can be applied to categorize the different interdisciplinary processes that a design framework should encompass to ensure a holistic and balanced approach.

Table 6: **Banathy's Process Lens**

| Processes | Description | Example Interdisciplinary Design Framework Processes |
|---|---|---|
| 1). Input processes | "**INPUT PROCESSING** implies operations that provide for interaction between the system and its environment or suprasystem" (Banathy, 1992, p. 102). | • Functional and user requirements gathering<br>• Competitive analysis<br>• Environmental scanning<br>• Recruitment of participants based on sample |
| 2). Transformation processes | "**TRANSFORMATION** implies operations that bring about conditions and activities by which the input is transformed into output, and the system is maintained/developed/changed" (Banathy, 1992, p. 102). | • Iterative design cycle<br>• Change management |
| 3). Output processes | "**OUTPUT PROCESSING** implies operations that bring about conditions and operations by which we provide for: (1) the identification and assessment of purpose(s)-relevant output, and (2) the dispatch of the output into the environment" (Banathy, 1992, p. 103). | • Usability testing<br>• Scope planning<br>• Quality planning |
| 4). System guidance/management processes | "**SYSTEM GUIDANCE/MANAGEMENT (FEEDBACK, ADJUSTMENT, CHANGE)** provide for the management/guidance of the system" (Banathy, 1992, p. 103). | • Final product evaluation<br>• Final project review<br>• Administrative closure |

Checkland (1981; 1999) also provides some additional processes and instruments for practitioners who wish to employ systems thinking methodologies. I posit that these system analysis tools also are applicable to design projects since they function as systems. Checkland suggests that there are two overarching types of systems analysis – hard analysis and soft analysis. Hard systems analysis tends to follow a very calculated and systematic approach. “The hard systems approach stems from two powerful roots, namely the rapid development of systems engineering in industry, and the widespread dissemination of systematic approaches to decision making from military to general government and organizational applications” (Naughton, 1984, p. 8). The hard approach to systems analysis is based on the assumption that clear objectives can be defined at the onset of a project and a definitive course of action taken to achieve those ends. This type of system thinking suggests that design problems can be investigated, deconstructed, and planned without ongoing input from the systemic environment.

Design projects, however, are social systems, for the artifacts they create are constructed by humans based on human needs. Social systems “are very different from natural and engineered systems. Natural and engineered systems can not be other than what they are. Human activity systems, on the other hand, are manifested through the perceptions of human beings who are free to attribute meanings to what they perceive” (Banathy, 1995, p. 1). Checkland (1981) suggests that these human activity systems (HAS) contain people or “actors” who envision the world differently based on their Weltanschauung or worldview. This worldview encompasses political, sociocultural, and economic ideologies that guide their thoughts and actions (p. 14). These beliefs, values, and attitudes, therefore, should be accounted for in the design process and it is this underlying philosophy on which soft systems analysis (SSA) rests.

The differences between hard and soft systems analysis parallels the distinction between positivist and constructionist philosophies. Positivist disciplines tend to often lean towards utilizing hard analysis and "problem-solving" approaches. As Remington and Pollack (2008) suggest, the traditional roots of project management take this tack "and emphasize efficiency of delivery and control to predetermined goals" (p. 142). Hard systems thinking, seems analogous with a quantitative approach to research where the emphasis is on attaining measureable outcomes and a detached stance is taken between the researcher and their subject (Palys, 2003, p.15).

In contrast, soft systems thinking tends to use a "problem structuring" approach. Schön (1987) describes this as the process of "problem setting" in which "interactively we *name* the things to which we will attend and *frame* the context in which we will attend them" (p. 40). This interactive framing or structuring, however, is informed by a constructivist perspective that advises we can only truly understand phenomena if we "understand something about how they're constructed and about the context in which they occur" (Palys, 2003, p. 13).

Remington and Pollack (2008) suggest that projects are becoming increasingly complex, ambiguous, and constrained. The "objective of soft system analysis is to bring about *change*—action to improve the situation" (Naughton, 1984, p. 46), and soft systems methodology (SSM) provides designers and managers with tools to deconstruct and frame complex and ambiguous design problems from a holistic context. Checkland's SSM utilizes a number of important instruments and processes of value in formulating an interdisciplinary design framework. While SSM could be utilized in its entirety at the early stages within this framework, I suggest that specific elements within the methodology are of particular value.

The first of these is what Checkland (1990) refers to as the creation of a rich picture. A rich picture is a cartoon-like diagram that depicts the problem situation as a whole from an objective perspective (see Figure 2). Checkland (1990) suggests, “that human affairs reveal a rich moving pageant of relationships, and pictures are a better means for recording relationships and connections than is linear prose” (p 45). At the onset of a problem situation stakeholders are consulted and information is collected and documented as project notes and/or sketches and a rich picture is formulated. The picture captures both “hard” information such as quantitative data and organizational structures, and “soft” information based on the worldviews of those actors. The picture depicts the processes and structures and their interdependencies.

Once formulated the rich picture is then reflected upon to identify the primary tasks and issues. The rich picture is a particularly potent instrument to resolve design problems as it draws upon the sketching abilities often inherent in designers. As Cross (2007) reinforces “the use of sketches is clearly an important part of the natural processes of designing” (p. 54). I concur with Cross that sketching facilitates the exploration of alternatives, enables identification and recall of information, and allows designers to perceive and explore problems from different perspectives without physical limitations. Rich pictures leverage all these characteristics.

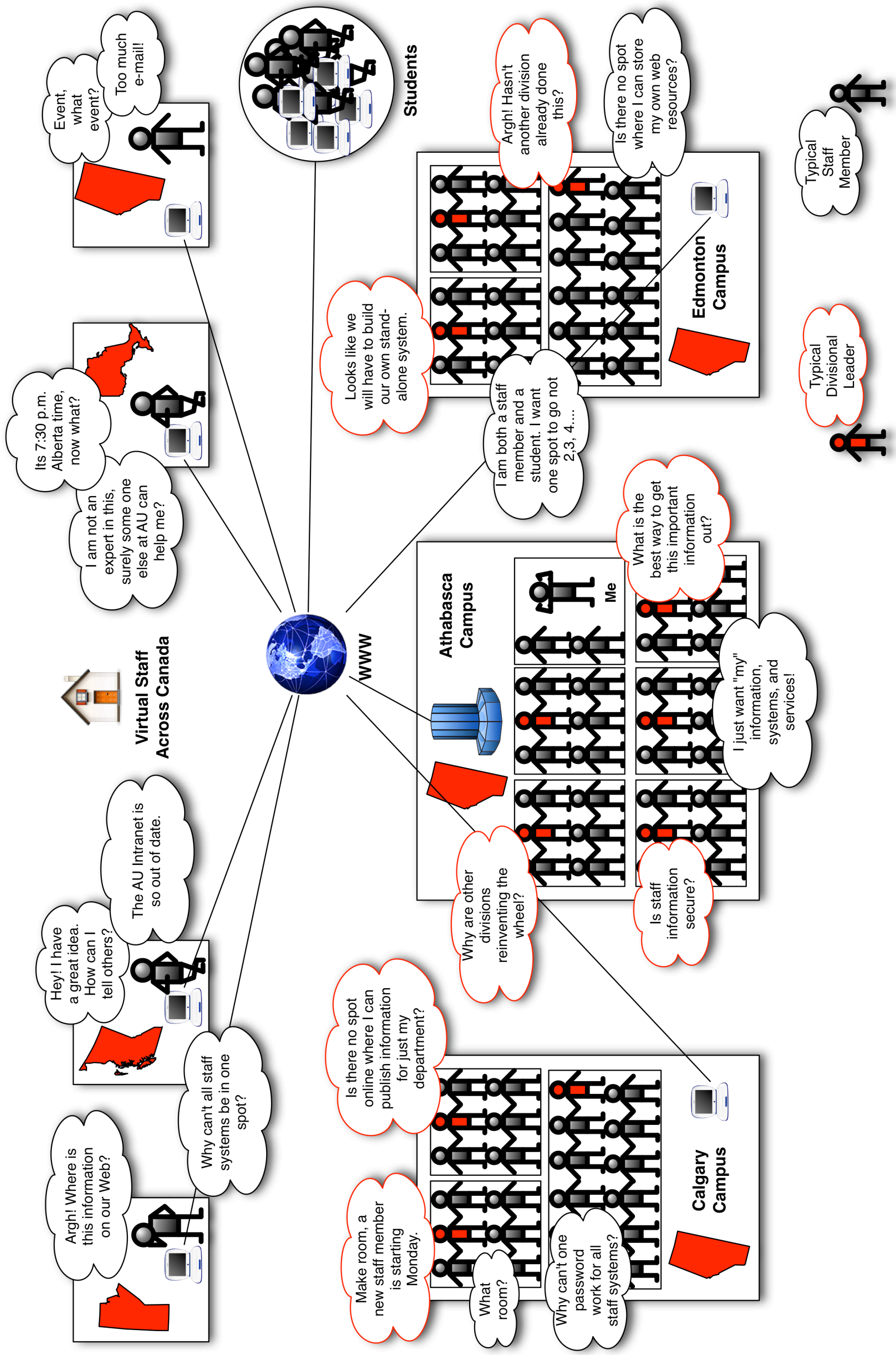



*Figure 2.* A Sample Rich Picture Based on Checkland's Soft Systems Methodology.

The second instrument of value distilled from SSM is what Checkland refers to as the “root definition.” The root definition is a statement that attempts to capture the essence of what a particular system is about. It formulates a transformative working statement that guides activities from the current problem situation as captured in the rich picture to what the relevant end system should achieve. A strong root definition should accurately embody and describe the end system to be realized, and performing a CATWOE analysis can validate the integrity and quality of the definition. CATWOE is an acronym for customers, actors, transformation process, Weltanschauung or worldview, owners, and environmental constraints. See Table 7 for a description of each CATWOE element.

Table 7. *CATWOE Elements*. Table 7 was created based on the text *Systems Thinking, Systems Practice* (Checkland, 1981). Similar to Banathy’s proposed system lenses (see Table 5 and Table 6) the application of this instrument helps inform the requirements gathering process and structuring of the design problem or opportunity. Checkland’s approach places more emphasis on understanding the worldviews of people (actors) associated with the system (the project) and their power relationships. That is, who may be victimized by the proposed solution, those who will utilize or sustain it, and those who ultimately control its livelihood or survival. Although there is some overlap between Checkland’s and Banathy’s instruments when used collectively they are powerful tools to form a holistic understanding of the design context,

Table 7: ***CATWOE Elements***

| C<br>**Customers** | A<br>**Actors** | T<br>**Transformation Process** | W<br>**Weltanschauung or Worldview** | O<br>**Owners** | E<br>**Environmental Constraints** |
|---|---|---|---|---|---|
| "C" stands for customers of the system. Those who are its victims or beneficiaries. | "A" stands for actors. The individuals who would carry out the transformative activities envisaged in the system being defined. | "T" stands for transformative process. What the system does to its inputs in order to transform them into output(s). | "W" stands for Weltanschauung or worldview. How the worldview will make the transformation process meaningful in context. | "O" stands for owners and those who have power to terminate the system or the transformation process. | "E" stands for environmental constraints. The given elements outside the system that it takes as given. |

The concept of establishing a root definition is similar to that of the nominal question used in research frameworks to guide the scope and nature of an area of inquiry, and it is subsequently used to formulate an operational approach to the object of study. Like the nominal definition the root definition may evolve as a project progresses.

In summary, Banathy's system lenses used collectively with Checkland's soft systems analysis techniques such as rich picture, root definition, and CATWOE analysis provide practitioners with powerful requirements gathering tools. Information collected allows clear and inclusive goals and project boundaries to be defined. This facilitates consensus building and management of stakeholder expectations. Systems thinking and methodology also reveals the interrelations of elements at work within a design project and its embeddedness. This helps frame the design problem and establishes the criteria that will guide an artifacts creation. More importantly, systems methodology and thinking can be utilized in multidisciplinary contexts; therefore, they are well suited for integration into an interdisciplinary design framework.

*A Synthesis of Interdisciplinary Design Elements*

Part 1 of this paper provided the reader with insight into the discipline of design and its interdisciplinary nature. It revealed specific skills that an interdisciplinary design framework should exploit and foster. These abilities can be honed through individual, team, or community-based learning or design activities. These skills, however, are not solely bound to design-related activities but can be applied equally in variety of learning contexts. Part 1 also highlighted processes and instruments from research, design, systems engineering, learning, and management knowledge areas that an interdisciplinary framework should encompass in order the needs of multidisciplinary design practitioners. Similar to frameworks in other knowledge areas these processes and instruments must be organized into a systematic series of phases that guide practice.

This set of interrelated phases is often referred to as a product or project life cycle. The proposed life cycle of an interdisciplinary design framework (Figure 3) encapsulates the underlying process groups and their inherent elements at work within an interdisciplinary design process: analysis, conceptualization, design, production, delivery, and closure. Life cycle phases are organized in a cyclic approach as a design project and the artifact(s) it engenders must be treated as living entities until such time the artifact is no longer active or the project deemed unviable.

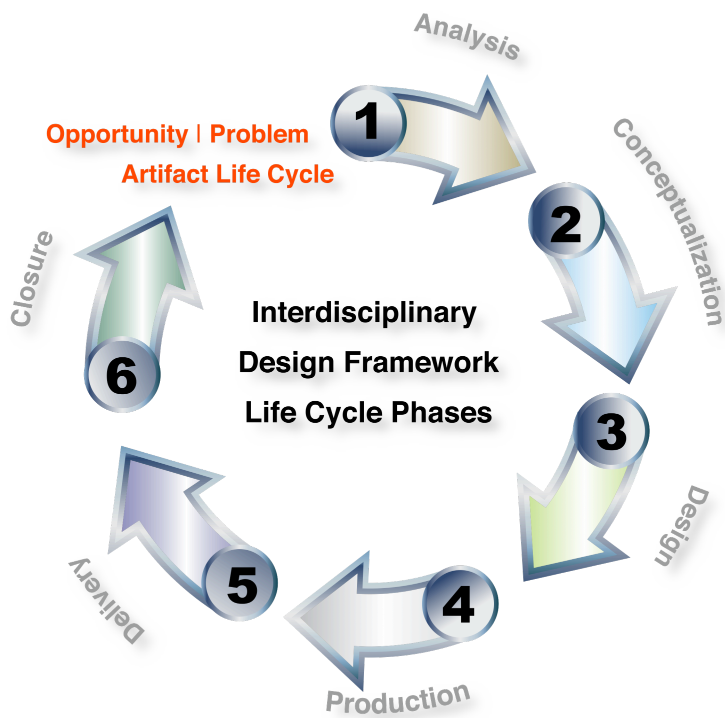



*Figure 3*. Interdisciplinary Design Framework Life Cycle Phases.

Figure 4 provides the reader with a synthesis of this analysis and illustrates how key elements from each of the knowledge areas identified in part 1 relate to each interdisciplinary life cycle phase. In addition, this analysis also led to the formulation of a set of guiding principles that should be reflected in the construction of the interdisciplinary design framework (see Table 8).

Part 2 of this paper will illustrate a proposed structure for the interdisciplinary design framework by drawing on this multidisciplinary analysis and my own knowledge and experience as a design practitioner. Part 2 further elaborates on the different processes, instruments, and outputs within each life cycle phase and how these various elements interact in a systematic approach to effectively address a design problem or opportunity.

*Figure 4*. Synthesis of Interdisciplinary Design Elements

Table 8: ***Guiding Principles In Formulating An Interdisciplinary Design Framework***

| **Principles** |
|---|
| That design is a multidisciplinary process shared amongst a broad range of disciplines. |
| That design is a creative process where intrinsic motivation is derived in part from a successful linking of problem and solution and the creation of an artifact that effectively balances form and function. |
| That designing is a natural ability that can be fostered by developing specific skill sets through knowledge and practice. |
| That artifacts possess different properties that limit their design capabilities. In addition, their application may be subject to domain-specific or environmental constraints. This knowledge, therefore, must inform the design process. |
| That the design discipline design lacks a standardized framework and supporting body of knowledge to guide practitioners. |
| That effective design is best realized as a social, inclusive, and participatory process that relies on feedback to guide an artifact's creation, develop practitioner's skills, inform the enterprise, and contribute to a community of practice. |
| That effective design reflects balances the needs of users/customers, the sponsoring business, and the environment. |
| That a design project must be aware of its embeddedness within broader systemic environments and that the artifacts it engenders often transcend their original contexts. |
| That practitioners as learners benefit from designing across different application areas, working on real-life design problems, participating on multidisciplinary teams, and sharing their knowledge. |
| That design projects are social systems and benefit from adopting a systematic approach to design and utilizing systems methodologies. That the paradigms of the people within the system guide their thoughts and actions. |
| That the design process involves people working collectively to resolve an ill-defined problem in a constraints-based context. Design projects and their inherent resources must be managed to resolve conflicts, mitigate risks, and control change. |
| That design is an iterative process where the end solution progressively emerges and cannot be predetermined. |
| That the design process benefits from a participatory approach that actively involves all stakeholders, end users of the artifact, and members of the design team. |
| That due to the iterative nature of design, and changes at work within the project environment, that there is no absolute or "perfect" solution to a problem. Rather, only the most appropriate solution within a given context. |
| That the design process must be objective and evidence-based. That both qualitative and quantitative data is necessary to formulate a holistic understanding of the problem situation and to know when a concept, artifact, or project may not be viable within its current context. |
| That an interdisciplinary design framework should be seen as a learning system and adopt processes that develop its users and evolve the framework itself. |
| That effective design is not spontaneous but requires sufficient time for research, reflection, and incubation. |
| That corporal of virtual work environments can be optimized to leverage an interdisciplinary framework's application to a design problem. |
| That a design project should not be treated as a temporary endeavor as long as the artifact it engendered is still active. |

## Part 2: The Interdisciplinary Design Framework

### *Structure and Application*

The structure of an interdisciplinary design framework emerges from an understanding that design is an interdisciplinary process. The process is instigated whenever the need arises to generate a creative artifact in response to an ill-defined and/or complex problem in a constraints-based environment. Constraints warrant that design problems are best structured as projects to ensure resources are effectively managed, risks identified and mitigated, change controlled, and communication ongoing. These control measures, however, must be structured to provide sufficient allowances for analysis, iterative experimentation, reflection, feedback, and validation, as these are integral to a creative and effective design process.

The framework should be seen as an adaptive and living system subject to change based on internal and external feedback. Internal feedback can come from the community of practitioners who utilize the framework and contribute to its supporting body of knowledge. External feedback would come from practitioners in other disciplines who possess insights for potential transformation.

The framework supports a systemic and systematic approach to design that encompasses both “hard” (quantitative) and “soft” (qualitative) methodologies. In particular, it fuses processes and elements from both user-centered design (UCD) and project management (PMBOK) frameworks. Miles (1998) noted the benefits of integrating soft methodologies into the predominantly hard and linear information systems engineering framework (p. 55). He suggested two means to achieve this, i.e.

grafting and embedding. In grafting, a soft systems approach (e.g., Checkland's Soft System Model, SSM) is grafted to the start of the existing framework. "In effect, a fuzzy problem situation, using SSM or parts thereof, is converted into a clearly structured problem to which a 'hard' methodology can be applied" (Miles, 1998, p. 56). The second approach, embedding, allows soft methodology to permeate throughout the host framework. Miles posits that the advantage of embedding is it fosters an ongoing interchange between users and the project team and provides a mechanism to expose and clearly define problems that arise during the project life cycle (p. 59).

An interdisciplinary design framework leverages the advantages of embedding, however, it is best perceived as a hybrid. It intermixes both soft and hard methodologies throughout its construct and is not based on a particular host framework but an aggregation of processes and instruments that hold interdisciplinary value. The framework's function is to provide practitioners from different disciplines with an apparatus that can be applied equally to resolve design problems across different knowledge areas. The framework, however, is optimized for creative design and production of man-made artifacts based on needs arising from ambiguous, complex, and constrained contexts. The rigour required to apply the framework, therefore, is not suited to simple problems with clear and lucid solutions. Furthermore, depending on the nature of the problem, the application of the framework in its entirety may also not be warranted, for example, when the desired artifact is realized before the framework has run its full course. In this case it suggested that practitioners still follow the prescribed phases in order, review the merits of each process and its outputs, and apply them accordingly. In this sense the framework can be used flexibly to inform best practice versus as a set of rules to be applied equally in all contexts. In addition, while design processes can be applied universally the properties of artifacts diverge across application areas; therefore, production processes and standards will vary.

An interdisciplinary design framework encompasses a team of experts from a broad range of disciplines organized into four teams: management, design, production, and operations. Based on an analysis of the design problem, its environment, and the artifact to be created specialized services or expertise may be solicited and assigned to one of these groups. In addition, a sample of the targeted end-users of the proposed artifact is recruited to the project team and actively participates in the design process. The management, production, and design teams are managed by a corresponding team lead and all team members share knowledge and work collectively on a design project throughout all of its phases. The operations team sustains an artifact once it has exited the final phase of the life cycle until its next iterative life cycle commences.

The project lead oversees all administrative tasks, functions as a project manager, and supervises the management group. This group is responsible for communication, change management, risk management, and performance management. The project lead is the primary contact for the project sponsor and the project community. As project lead they assume overall authority and responsibility for the health of the project and resolve any performance issues, quandaries, or impasses that arise. A team of marketing specialists, system/process analysts, researchers, and administrative support personnel supports the project lead.

The design lead oversees the design group and is responsible for the end-user experience and all aspects related to the “look and feel” and usability of an artifact. A team of visual designers, industrial designers, human-interaction specialists, and internationalization specialists support the design lead. The technical lead is responsible for the production group and all aspects related to the production of an artifact including its functionality, performance, quality, and reliability. Service specialists, engineers, and technicians support the technical lead.

During different project phases different groups will be more active than others, however, all team members actively provide feedback and share expertise as the project progresses. Team leads function as both supervisors and mentors. They facilitate a learning environment where experts and novices interact and share knowledge and experiences as they collectively develop the artifact.

The following sections provide an overview of each life cycle phase within the interdisciplinary design framework. Throughout these phases instruments are suggested to aid practitioners in completing phase-related processes. These instruments are by no means exclusive and like the framework itself are adaptable and open for improvement. Detailed descriptions about how to employ these instruments are not provided as this aspect is beyond the scope of this paper and more detailed information is available from alternate sources.

## PHASE 1: ANALYSIS

Figure 5 provides an overview of Phase 1 and its inherent processes, outputs, and their interactions. The analysis phase is initiated when a new design-related problem or opportunity arises from the external or internal environment (item 1). This results in the sponsoring of a design project to either create a new artifact or the redesigning of an existing artifact. A redesign can only be initiated if the existing artifact was sponsored by the same entity and the artifact's life cycle plan and archives can be accessed. In both cases the projects are treated objectively and no assumptions are made that existing solutions are appropriate to address current needs.

The project management framework (PMBOK) suggests that "a project is not formally charted and initiated until completion of a needs assessment, feasibility study, preliminary plan, or some other equivalent form of analysis that was separately initiated" (PMI, 2004, p. 81). These activities, therefore, are conducted in isolation and treated as external processes that occur outside the project framework. The proposed function of these activities is to assess the business viability of a project before allocating resources.

In an interdisciplinary design framework feasibility and needs-related activities are integrated into the analysis phase via the stakeholder analysis, environmental, analysis, and artifact analysis processes. The interdisciplinary design team is collectively involved in all life cycle phases and their contributions to the analysis phase provide insight into the potential viability of a project from multiple standpoints.

The information generated from analysis is integrated into the design brief that acts like a project proposal. Once the design brief is completed the merits of the project are reviewed and evaluated by the project sponsor in conjunction with the three team leads as part of the framework's first phase gate (item A). Phase gates "are part of a generally sequential process designed to ensure proper control of the project and to attain the desired product or service, which is the objective of the project" (PMI, 2004, p. 22). Phase gates provide an opportunity for the project sponsor to provide feedback or terminate a project. They also provide the project team with a staging ground to reflect on their work, validate assumptions, and strategize for subsequent phases.

The specific function of the stakeholder analysis process group is to ascertain the needs of the sponsoring business and those of the target users/customers of the proposed artifact. These needs may not be in alignment with each other and this process aims to objectively establish artifact requirements from both perspectives. The purpose of the environmental analysis process group is to assess the need and impact of the proposed artifact within its internal environment and the environment(s) in which it will be embedded. This process assesses how a new artifact will impact and relate to existing artifacts and processes in these environments. In addition, this process group analyzes the primary competitors within the external environment, their artifacts, and potential new markets or areas of application.

The artifact analysis process group researches the properties of the proposed artifact so design requirements can account for constraints imposed by these properties.

In addition, these processes explore any industry-related standards that will impact an artifact's design, manufacture, or integration with its future environments.

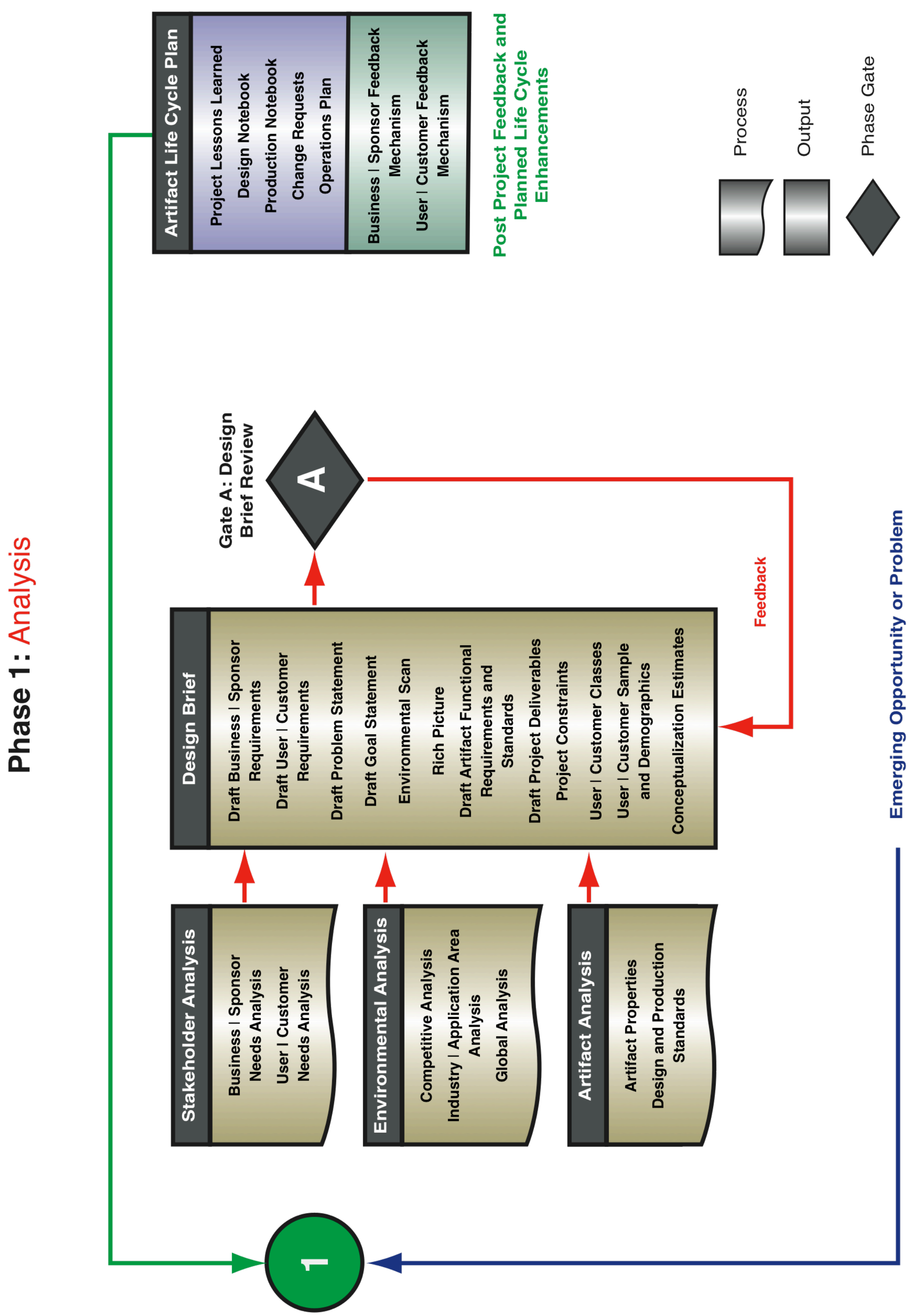
Stakeholder analysis, environmental analysis, and artifact analysis processes are best accomplished by using research inquiry and systems analysis techniques. In particular, utilizing Checkland's soft system methodology (SSM) in conjunction with Banathy's three system lenses provides a holistic and objective understanding of how the problem/opportunity can be achieved and the information collected can be aggregated into the design brief. The design brief contains foundational information that informs the succeeding life cycle phases and reveals indicators as to the potential viability of a proposed project and its artifact.

The design brief should be treated akin to a research proposal. It should reveal existing knowledge and artifacts of pertinence, the relationship of the project and proposed artifact to these articles, define project aims and objectives, and outline the proposed approach to understanding and evaluating problem. The design brief includes the following components: business, customer, and artifact requirements, draft problem and goal statements, environmental factors, a rich picture, draft project deliverables, user data, artifact data, and an estimate of the resources required to complete the project and realize the artifact. Once the sponsor approves the design brief the interdisciplinary design team is granted authorization to execute the subsequent conceptualization phase where the viability of the project and any assumptions will be further substantiated.

Table 9: ***Synopsis of Benefits From the Analysis Phase***

| **Attributes** |
| --- |
| Team participation in analysis aids the team collectively understanding the problem situation. Furthermore, as the team is comprised of multidisciplinary experts it allows each team member to contribute their unique perspective allowing a more holistic understanding of the problem to materialize. |
| Stakeholder analysis balances the needs of the sponsor/business with those of the targeted end-users/customers. This approach ensures the end solution delivered meets requirements and is acceptable by both primary stakeholder groups. |
| This phase reflects the philosophy that a project is not fully terminated once it delivers an artifact into its environment. A design project is a system; therefore, as long it is active it must be sustained, supported, and monitored to inform its adaption and evolution. |
| The analysis phase converts an ill-defined problem into an unambiguous understanding of the problem and the constraints imposed by the project context. This conversion is aided by an objective approach to research that combines the benefits of both qualitative and quantitative methods |
| The phase gate at the end of the analysis phase provides an opportunity for business stakeholders to provide feedback and align with the project team on nature of the problem, and requirements. More importantly, it provides time for the team to collectively and individually reflect on the project and strategize for conceptualization. |
| The adoption of systems thinking facilitates the ability of team members to develop a macro-micro perspective of design problems. Soft system analysis techniques deconstruct the design problem revealing the elements at work within the project and its environment and their interrelations allowing more accurate logistical planning to occur. |
| Blends strong problem structuring and problem solving methodology from research design, systems design, user-centered design, and project management disciplines. |

*Figure 5*. Life Cycle Phase 1: Analysis



## Phase 2: Conceptualization

The second life cycle phase in an interdisciplinary design framework is conceptualization (see Figure 6). The first phase of the cycle was focused towards deconstructing the design problem to formulate a general understanding of project goals, requirements, deliverables, and constraints. In addition, it generated demographics and a target population for each user class that would utilize the proposed artifact. The conceptualization phase interprets the observations and data collected during phase 1 into benchmarks, use-cases, and prototypes that representative users from each class will validate as part of the project team. This corroboration will allow an optimized low fidelity prototype and success criteria to materialize. This strategy allows the formulation of an evidence based project plan to govern an artifacts realization.

This approach deviates from other frameworks (e.g., PMBOK, UCD) where planning precedes the execution of design-related activities. An interdisciplinary design framework, however, recognizes that a degree of preliminary design work, feedback, and validation is required in advance of planning. This not only results in proof of concept, it generates more accurate information to guide project planning and management.

During the initial logistical planning process the official project team is formulated. Depending on the nature of the artifact to be created external expertise may be solicited and integrated into the team. Through the process of narrowing (see Design and Learning) the project team optimizes their virtual or corporal design studio to facilitate learning, communication, and familiarity with the design problem. Roles and responsibilities, information sharing instruments, and revision/change control procedures are deliberated. Based on the design brief the team works collaboratively on understanding and analyzing the problem/opportunity and formulating three alternative design strategies with additional research being conducted as required. In my experience four alternatives provides too many choices and two alternatives not enough. Three alternatives ensure that the problem or opportunity has been explored from a least three unique perspectives.

A common set of use-cases, usability tests, user profiles, and benchmarks are drafted and sample users are recruited for each user class identified during the analysis phase. These users are integrated into the design team and consulted throughout the conceptualization, design, and production phases. Use-cases define the typical task scenarios associated with the user and the artifact. Usability tests document the experience of users engaging with the artifact and evaluate results against desired benchmarks. User profiles outline customer attributes such as: gender, age, values and beliefs, status, interests, nationality, motivations, worldview, and technical aptitude. These tools function as a reference points from which project team members can validate their assumptions and proposed solutions.

During the conceptualization process a low fidelity prototype is created for each alternative solution along with a breakdown of perceived tasks, benefits, and risks. Low fidelity prototypes are simple conceptual aids (e.g., sketches, models, wireframes) that can be used to demonstrate the key properties and concepts associated with a proposed artifact. A work breakdown structure (WBS) is used to identify and group related tasks, assign task responsibility, and record task status. The Gantt chart establishes a timeline for the project based on task duration and inter-task dependencies. Risks are documented in a risk register that contains risk indicators and contingency plans. The WBS, Gantt, and risk register is updated throughout the duration of the project and jointly managed by the three project leads.

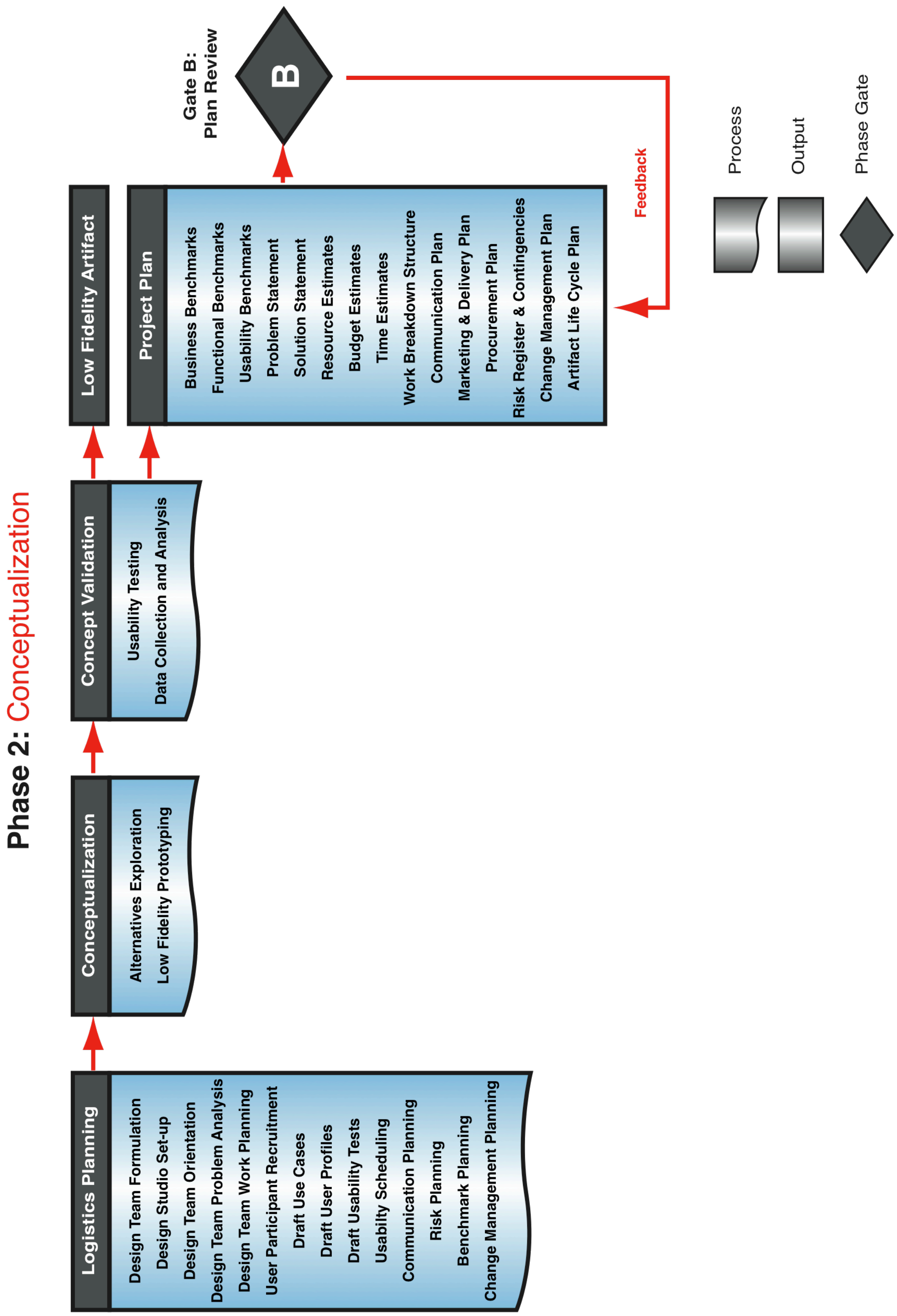
During the concept validation process each user class evaluates the three prototypes via use-cases and usability tests. Data collected reveals the most appropriate solution to pursue, required changes to refine the design, success criteria, and insight on the true nature and scope of the project. This approach allows more accurate project planning components to be formalized including a more definitive problem/solution statement, improved identification and allocations of resources, clearer evaluation criteria, and barriers or risks to success.

The end result of the conceptualization phase is the bridging of an ill-defined design problem into a proposed solution space. Management, design, and production teams can now structure their plans in accordance with the artifact’s forecasted design path and lifespan. The team leads presents these plans, findings, and the recommended low fidelity artifact to project sponsor(s) as part of the life cycle’s second phase gate (item B). The sponsors provide feedback or can opt to terminate the project. Should the project be terminated the project would jump to the closure phase. Should the project proceed then the project team utilizes this phase gate as an opportunity to reflect on the design and prepare for the subsequent design phase.

Table 10: ***Synopsis of Benefits From the Conceptualization Phase***

| **Attributes** |
|---|
| Actively recruits and integrates users into the project team as part of a participatory design process. This generates feedback that further refines requirements and validates design decisions. |
| Prescribes to actively seeking three alternative solutions to the design problem and an evidence-based approach to inform the selection. The most appropriate solution is pursued while working within inherent project constraints. |
| Leverages the visual and spatial skills often inherent in designers by using prototypes to convey concepts. |
| Supports the philosophy that a design project cannot be pre-planned. Accurate planning requires conceptualization and validation of a proposed solution in advance to accurately reveal and account for criteria that will naturally emerge from the design process. |
| Acknowledges that a design project must be resolved within a constraints based context. |
| Reflects that the design studio, whether virtual or corporal, must be optimized to facilitate learning and effective design. |
| Facilitates the development of a micro-macro perspective of design problems amongst team members by employing the use of Gantt charts to develop a micro view and work breakdown structures to establish a macro view. |
| The phase gate at the end of this phase provides an opportunity for business stakeholders to provide feedback on the plan, approve the project, or terminate it if it is not economically viable. More importantly, it allocates time for the team to reflect on the plan and the low fidelity prototype and devise their next iterations. |
| Blends strong approaches to planning, risk management, change management, and iterative design from user-centered design and project management frameworks. |

*Figure 6*. Life Cycle Phase 2: Conceptualization



## Phase 3: Design

During the design phase (see Figure 7) the project team transforms the low-fidelity prototype into a medium fidelity prototype, and consequently into a high fidelity prototype in anticipation of production. The detail inherent within each of these prototypes will vary depending on the nature of the artifact and its area of application. The high fidelity prototype, however, should clearly mimic the end-user experience and be supported by sufficient specifications from which the artifact can be constructed. The endorsed project plan, iterative design process, and design validation process guide the creation of these prototypes.

The team reviews feedback and changes resulting from the design validation process as part of a group critique facilitated by three project leads. The goal is not only to improve the artifact's design but foster knowledge exchange and skill development amongst team members. Changes, minutes, production notes, future life cycle concepts and other pertinent information are documented in a readily accessible team design notebook. In addition, team members are encouraged to keep their own private learning journals. When required and appropriate the team may consult the broader community of interdisciplinary practitioners via social networks or access knowledge repositories. Based on team consultation the team leads select the most appropriate changes while working within imposed project constraints.

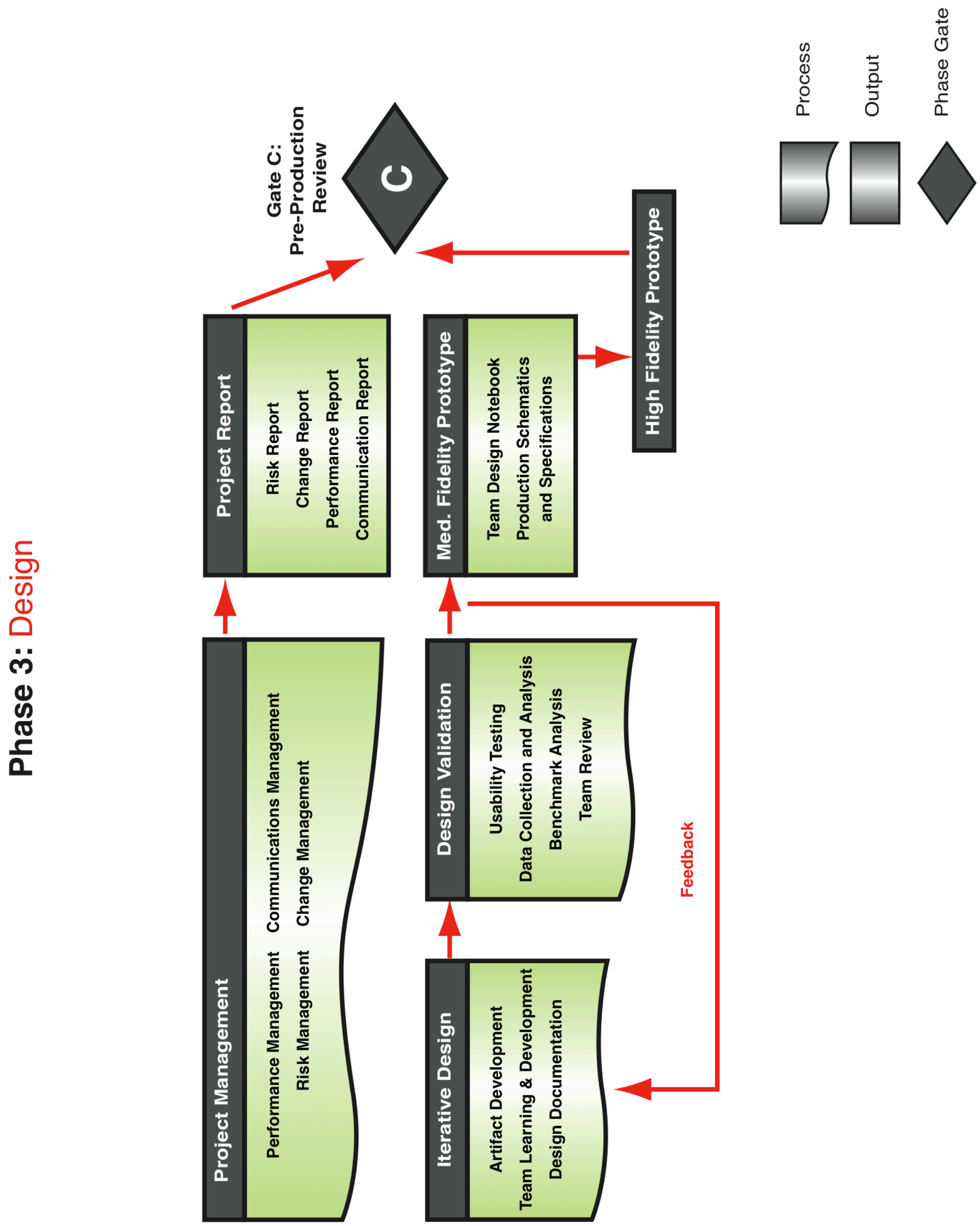
The project management team monitors for risks identified in the register or any other factors that will impact the project schedule or budget, in particular proposed design changes that will jeopardize the schedule or budget. These are communicated to the project sponsor for approval prior to implementation and the WBS and Gantt updated accordingly. A report summarizing risk monitoring activities, communication activities, design changes, and project performance is provided to the project sponsor at regular intervals throughout this phase and for the balance of the project.

Once a high fidelity prototype is conceived it is presented to the sponsor by the team leads as part of the final phase gate (item C). This gate is the last opportunity to cancel the project before the artifact goes into production. Should the project be terminated the project would jump to the closure phase. Should the project proceed then the project team utilizes this phase gate as an opportunity to prepare for production.

Table 11: ***Synopsis of Benefits From the Design Phase***

| **Attributes** |
| --- |
| Recognizes that design is an iterative process requiring cycles of feedback, reflection, and subsequent action. |
| Reflects the importance of changing the design based on feedback and benchmarking, however, it monitors and controls high impact changes that will cause major deviations in time, money, or resources. |
| Incorporates ongoing reporting mechanisms to keep the project sponsor, teams, and plans up-to-date. |
| Facilitates the development of communication skills amongst team members through participation in group-based activities (e.g., critiques, team design notebook). |
| Stresses the importance of individual and collective documentation to facilitate learning and planning. |
| Facilitates learning through mutual problem solving, knowledge exchange, and reflection on experiences. |
| Acknowledges the design is a social process best conducted by a diverse team. Furthermore, that the design process and the interdisciplinary design framework benefit from teams participating in a broader community of practice and contributing to a supporting body of knowledge. |
| Blends the best approaches from user-centered design and project/product management frameworks. |
| The final phase gate at the end of the design phase allows the team to reflect on the production implications of the design and work with the production team to transition to the production phase. It also provides a final chance for the project sponsor to terminate the project before initiating the subsequent life cycle phases. |

*Figure 7.* Life Cycle Phase 3: Design



## Phase 4: Production

The production phase is comprised of four process groups: project management, logistics planning, production, and validation (see Figure 8*).* During this phase the artifact and any related project deliverables are constructed, validated, and prepared for delivery. As part of the project management process group the management team monitors issues that may jeopardize the health of the project. The project lead provides ongoing reports to the project sponsor summarizing performance management, communication management, risk management, and key production decisions and changes.

During the logistics planning process the team procures any production-related expertise, goods, services, or facilities. Under the direction of the technical lead the production team is assembled, oriented, and assigned tasks based on the project plan. Production tests are formulated based on benchmarks and a team production notebook is created. This notebook mirrors the design notebook established during the design phase and is used collectively by the production team to document all production-related information (e.g., defects, notes to aid subsequent reproduction, future design concepts). Team members are encouraged to contribute to this notebook, participate in ongoing group critiques of the products as they are constructed, and share knowledge and experiences. In addition, team members are also instructed to establish their own learning journals to document their tasks, observations, and insights. Production facilities are optimized for construction of a single artifact or its mass replication based on the needs of the project. Under the direction of the project lead the project team works collectively on operational plans (e.g., integration plan, maintenance plan, support plan, training plan, decommissioning plan) that will aid with the integration of the artifact into its environment and support its sustainability over its planned life cycle.

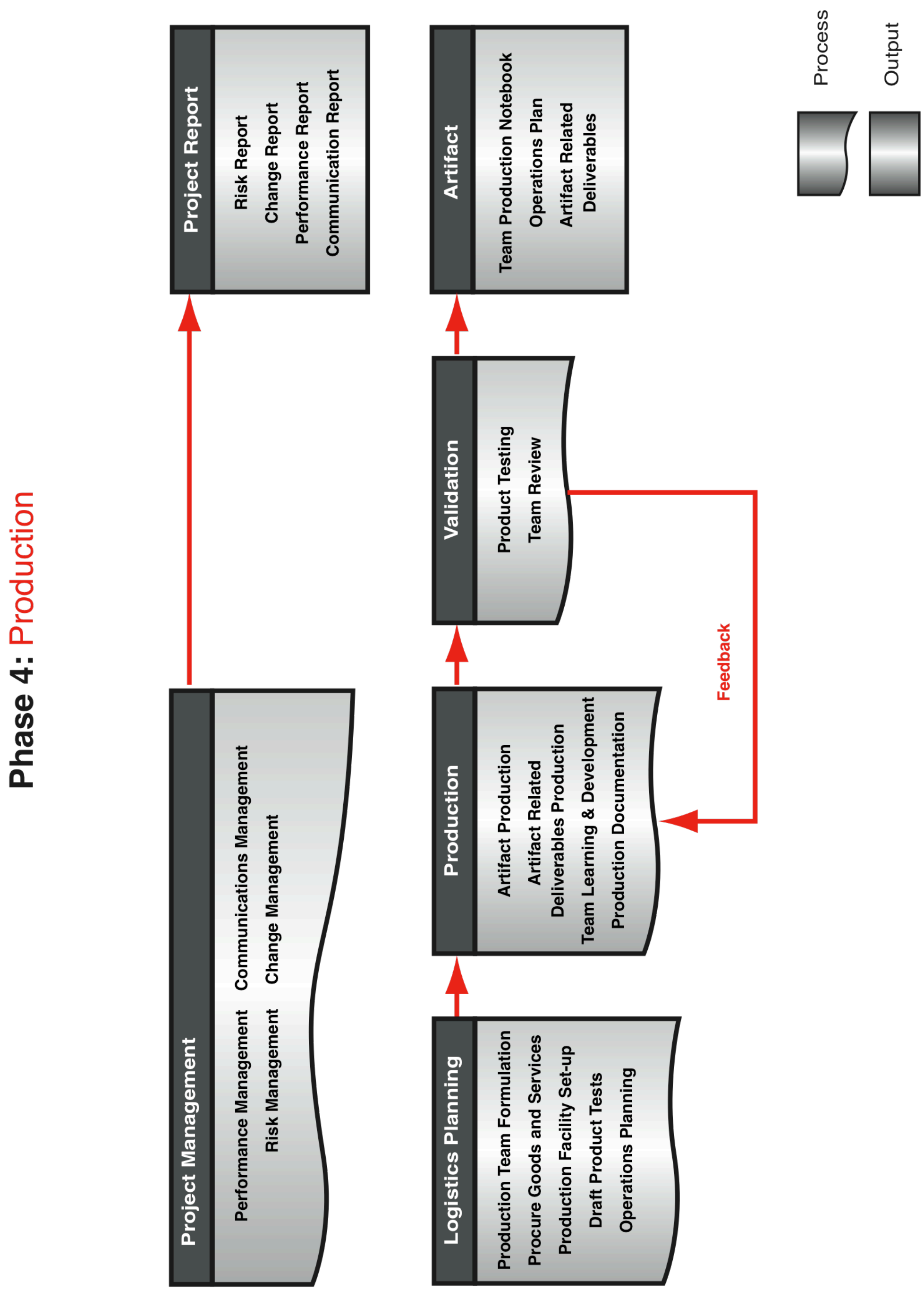
During the production process the production team creates the artifact(s) and any related project deliverables under the direction of the technical lead. The production team is further guided by their interactions with the project since its beginning, the project plan, ongoing interactions with the broader project team, and by referencing the high fidelity prototype and its schematics. These deliverables are evaluated during the validation process group against defined quality assurance and usability tests. Feedback is reviewed as part of a group critique and bugs, defects, or recommendations for change documented in the production notebook. Based on team feedback the production lead, design lead, and product lead initiate low impact changes as required until product benchmarks are satisfied. Significant changes that will impact the project schedule or budget are relayed to the project sponsor by the project lead for approval prior to implementation and the project WBS and Gantt are updated.

The end result of this phase is the creation of the artifact and its related deliverables, an operational plan, the production notebook, and a project report. These items set the stage for the following delivery and closure phases.

Table 12: ***Synopsis of Benefits From the Production Phase***

| **Attributes** |
|---|
| Recognizes that effective production is an iterative process like design that requires cycles of feedback, reflection, and subsequent action. |
| Reflects the importance of monitoring and controlling quality assurance changes that may cause major deviations in time, money, or quality. |
| Incorporates ongoing reporting mechanisms to keep the project sponsor, teams, and plans up-to-date. |
| Facilitates the development of communication skills amongst team members through participation in group-based activities (e.g., product critiques, collective contributions to the team production notebook). |
| Stresses the importance of individual and collective documentation to facilitate learning and planning. |
| Takes a team-based approach to instigating a product change to ensure the end artifact still complies with design requirements and user/sponsor expectations. |
| Reflects that production facilities can be shaped to streamline productivity and facilitate learning. |
| Blends the best approaches from user-centered design and project/product management frameworks. |

*Figure 8*. Life Cycle Phase 4: Production



## Phase 5 and 6: Delivery and Closure

The delivery life cycle sets the stage for hand-off of the artifact and its related deliverables to the project sponsor and end-customers. Despite the final delivery of the artifact into its end environment an interdisciplinary design framework envisions the life cycle of its engendered artifact as ongoing. An artifact delivered reflects only the most appropriate design solution at a given point in time based on the constraints imposed by the project context. The artifact, therefore, is always subject to improvement if there is an ongoing and viable need to sustain its existence.

The artifact life cycle plan created as part of the conceptualization phase forecasted the intended lifespan of the artifact and functions as a roadmap for its future development. Upon project closure this plan is updated based on information attained from the project and from ongoing feedback received by users engaged in the artifacts use. Redesign or enhancements are triggered based on planned upgrades reflected in the artifact life cycle plan or when a new problem or opportunity arises from the artifact's environment. The artifact and its users are sustained throughout its planned lifespan by the operations plan and its inherent resources

The delivery process establishes the marketing and communication mechanisms required to promote and/or raise awareness of the implications associated with an artifacts upcoming release into its environment. This communication allows users within the environment to seek the artifact out or prepare for its arrival and integration. In addition, the delivery process group establishes the communication channels to solicit ongoing feedback from the artifact's sponsor and end-users upon delivery. The type of feedback mechanism created (e.g., customer satisfaction survey, support network) will vary based on the properties of the artifact, its life cycle, and budgeted resources. Feedback attained from sponsors via these channels updates the artifact life cycle plan that contains the operational plan, future feature/change requests, design and production notebooks, and project lessons learned.

The operations team monitors feedback and if warranted in consultation with the project sponsor takes corrective measures to improve quality, update the operational plan, and aid users. However, the purpose of the artifact life cycle plan is not to respond reactively to changes as they arise, but to document changes throughout an artifact’s lifecycle to inform future design plans.

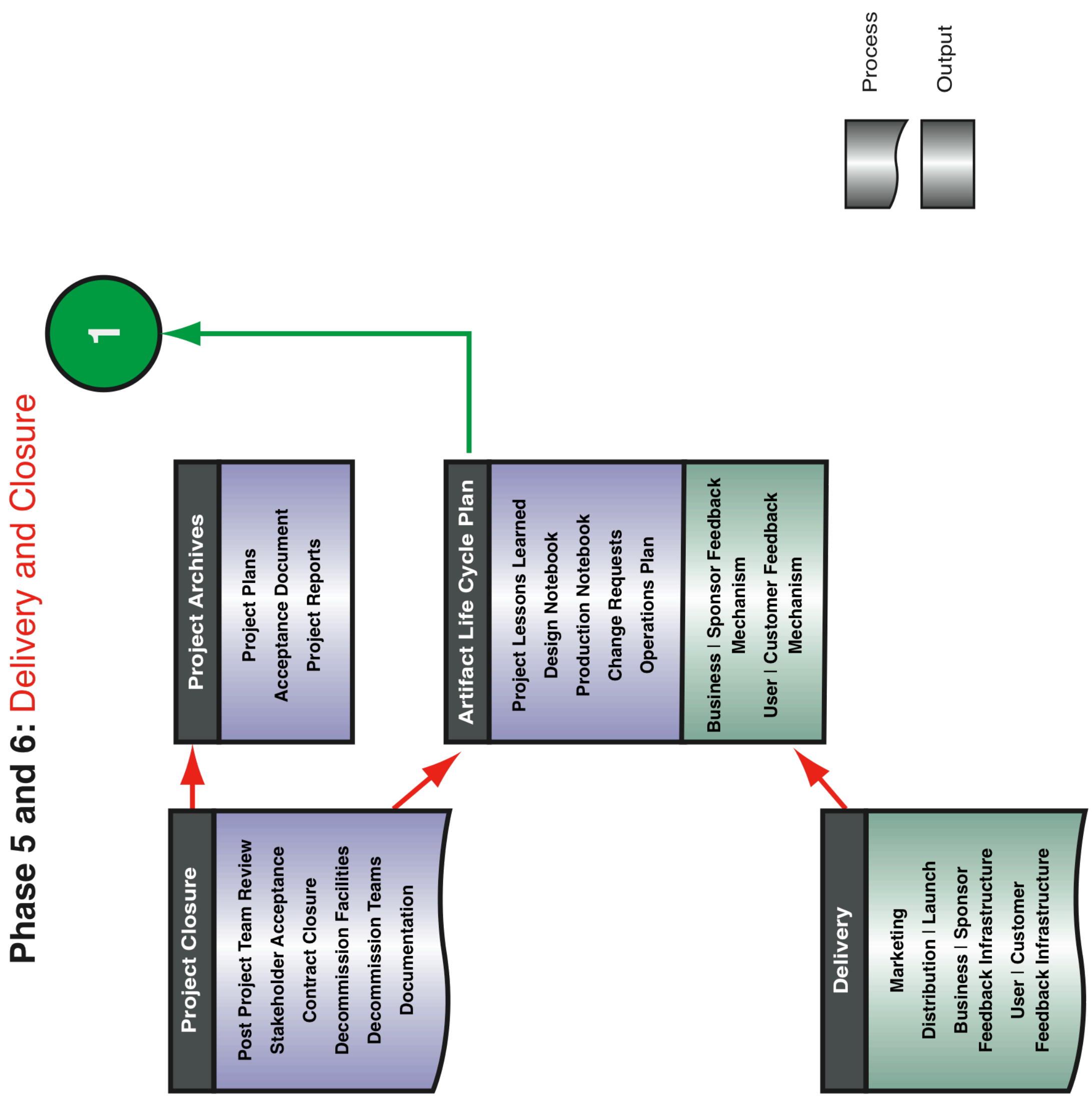
During the project closure process group the team conducts a post project review to reflect upon and discuss their project experiences. Suggested collective improvements to project management and administration are documented in a project lessons learned report. Insights that are design or production-related are added as updates to corresponding design or production notebooks. All three documents are integrated into the artifact life cycle plan. Personal insights are recorded in the individual learning journals of team members. The project lead attains sign-off from the sponsor that the artifact and its related deliverables are satisfactory. This acceptance document, as well as copies of the project brief, project plan, and project reports are stored in a project archive.

During closure the operations team is oriented by the project team and assumes control over the project and sustains and supports the artifact based on the operational plan. In addition, the operations team maintains and updates the artifact life cycle plan and the project sponsor and project team have ongoing access to review and/or contribute to its content. Closure processes conclude with facilities being decommissioned, contracts closed, and the team disbanded or reallocated to address new problems or opportunities.

Table 13: ***Synopsis of Benefits From the Delivery and Closure Phases***

| **Attributes** |
| --- |
| Reflects the philosophy that an artifact is tied to the system of its origin (the project) and the system(s) in which it is embedded (its environment). These links are dynamic in nature and an artifact must adapt and evolve based on feedback it receives from these sources as long as there is a need for its existence. |
| Acknowledges that operational processes are an integral part of an artifact's life cycle as they sustain its functions, support both its creators and users, and capture feedback that can inform its next iteration. |
| Illustrates that artifacts impact their environment upon delivery, therefore, their arrival or integration warrants advance communication and planning. |
| Facilitates individual and team-based learning through the post project review process and ongoing reflection and contributions to the artifact life cycle plan. Knowledge and experiences are assimilated into individual or team-based practice. |
| Supports Schön's (1987, p. 79) principal that effective design is not reactive but reflects-in-action allowing a more strategic and planned approach to problem solving. |
| Blends the best approaches from user-centered design and project/product management frameworks. |

*Figure 9.* Life Cycle Phases 5 and 6: Delivery and Closure.



## PART 3: AN INTERDISCIPLINARY DESIGN FRAMEWORK IN PRACTICE

The following fictitious scenario provides an overview of how the initial analysis phase of the proposed interdisciplinary framework can be applied to a particular situation. In an ideal context the framework would be supported by management, design, production, and operational team leads. Each lead would have a corresponding team of experts who would work collectively with a set of representative users associated with the artifact to be engendered. In some cases, however, the lack or resources, the structure of an organization or company, or other environmental factors may warrant adapting the framework to address the unique needs and constraints imposed by the project context. It is suggested that the framework and its inherent processes and instruments are highly adaptable and can be applied universally to address multidisciplinary design problems or opportunities in these contexts.

### *Background*

Ground Zero Communications is a small company based in Halifax specializing in landscape design. The company supports the philosophy of design being a universal process and therefore has adopted the interdisciplinary design framework to inform its practice over the last four years. The company has also been actively contributing to the framework's supporting body of knowledge through their interactions with other practitioners via a well-established online community. The company is comprised of four permanent staff members who have been individually developing expertise in parallel to the team structure suggested by the framework. These include the founder of the company functioning as project lead, the landscape architect functioning as design lead, the production coordinator serving as technical lead, and an operational manager. The founder of the company assumes overall responsibility for the management and administration of all projects; however, all four members contribute equally in the design process for each project the company selected to undertake. Two full-time assistants support the four partners, one with expertise in research and analysis, and another with a background in business administration and marketing. Both of these assistants were relative newcomers in utilizing the interdisciplinary framework so the four primary members had assumed mentorship roles actively fostering their design skills through participatory practice and demonstration. The company recruited or contracted specialized services or expertise as dedicated by the specific needs of the project.

Recently the company had received a regional environmental design award for an urban landscape completed in conjunction with a newly constructed building in downtown Halifax. This award and the popularity of the design by the local press and community gained the attention of Open-Air Furniture Incorporated (OAF), an international company specializing in custom outdoor furniture for both consumers and commercial industry. OAF requested that Ground Zero create a comparable design to accompany one of their buildings being currently constructed in the middle of a small town just outside Quebec City. The building site possessed 20 acres of undeveloped land that needed to be landscaped to complement the new building. OAF did not know exactly what the landscape design should encompass but wanted to mimic specific features of the award-winning design and reflect the innovative nature of their products and services. The ambiguous nature of the project and its inherent complexity, therefore, confirmed Ground Zero's assumption that the utilization of the interdisciplinary design framework was warranted.

Ground Zero confirmed that they were interested in the project but emphasized that each design project possessed unique characteristics based on its particular context. For example, different stakeholder needs, cultures, building protocols, and climates warranted an in-depth analysis of the context to define the appropriate approach. They suggested that some features of the award winning design could be ported to their project; however, it would advantageous and logical to adapt the landscape to the unique needs and constraints imposed by the project and its environment.

Ground Zero recommended that they forge an initial contract that would focus on conducting a thorough analysis of the opportunity to accurately define requirements and goals prior to commencing any actual design work or formalizing a strategy. They suggested that this initial phase allowed OAF to fully understand the potential scope of the project and its ramifications prior to committing substantial resources. In addition, it would allow to the two parties to establish a common ground to make sure they were "on the same page". They suggested the end deliverable of this initial phase would be a design brief that summarized the scope of the opportunity, its requirements and needs, and provided an estimate to convert the findings into a conceptual approach and project plan. Open-Air agreed with the logic of this approach and a contract was negotiated and funding granted to complete the analysis phase.

*The Analysis Phase*

At the onset of the analysis phase the project lead worked with the two assistants to create the communications infrastructure required to support the project. Since the two companies were separated by a substantial distance telecommunications technologies (e.g., teleconferencing, video-conferencing) were established. Additionally, two secure and private websites were also created. An extranet between OAF and Ground zero management to facilitate file exchange and project management activities including communications reporting, change reporting, risk reporting, and performance reporting. The second website would be accessible only to the members of the project team and housed the design and production notebooks used to document meetings, decisions, concepts, work tasks and timelines, roles and responsibilities, research data, and other information pertinent to the creation and sustainability of the landscape.

OAF wanted to mimic specific features of the award winning design so Ground Zero consulted information associated with the Halifax project. Since the company had been adhering to the interdisciplinary framework it was to able access the project archives, life cycle plan, and ongoing feedback collected from the preceding project. Once this information was attained the team held a brainstorming session comparing the two projects. This provided the team with insight on how to improve on the prior design and production of OAF's desired landscape features and identified key project differences and similarities. These former records also provided the team with a set of templates that could be adapted to meet the unique needs of the current project and allowed the team to draw on previous knowledge to inform the current design process. As a result it became readily apparent that none of Ground Zero's employees were familiar with French language or culture, therefore, a specialist would be required to aid in translation and bridge any potential sociocultural gaps. In addition, that a general contractor in the vicinity of the project site would need to be hired to coordinate procurement of the required goods and services on location. The team consulted the online community of interdisciplinary design practitioners and advertised their need to potentially procure these services. As a result they received some pertinent information about the area in question and identified a few interested parties willing to join the team.

A stakeholder analysis was conducted by Ground Zero to better understand OAF's organizational structure, culture, brand, products and services, market, competitors, strategic business goals, and clarify specific project goals. In consultation with OAF management the team defined the different types of stakeholders (e.g., employees, customers, general public) who would utilize or be impacted by the end design. Identified stakeholder groups were further subdivided into specific user classes. Demographic data was collected for each class and draft user profiles established. Through advertisements in OAF's staff and customer newsletters and the local newspaper stakeholders from each user class were solicited to participate in a series of class-specific focus groups. OAF provided incentive by offering a chance to win a custom suite of furniture for participants who were selected to partake in the study. The entire Ground Zero team facilitated each focus group in-person and focused the dialogue to ascertain the needs, desires, and issues of each class. The team was careful not to suggest and solutions and to try and stay objective throughout the inquiry.

Information documented informed the creation of a set soft system analysis tables based on Banathy's (1995) system-environment, functions-structure, and process lenses (see Figure 1, Table 5, and Table 6). Checkland's (1981) CATWOE and rich picture techniques (se Figure 2 and Table 7) were also used and collectively these techniques provided a holistic understanding of the project and its environment.

An environmental analysis was also conducted to uncover environmental factors that would impact the design, production, or sustainability of any proposed solution. Some of these activities included a review of building plan blueprints to determine how best to integrate both landscape and architectural designs, and assessment of the properties inherent in the undeveloped land, and a review of the surrounding environment and community. An additional investigation was undertaken to determine such factors as local development protocols, construction standards, climatic conditions, and availability of manpower and resources. All this information was entered in team's design and production notebooks.

During these analysis processes one of the members had an idea for a personal design project they had been working on which they recorded in their personal learning journal. A couple of other team members had gained some creative insights on the current project and these were recorded in the design notebook. In an effort to leverage narrowing techniques copies of the rich picture, user profiles, problem statement, and solution statement were enlarged and placed on the studio walls for reference. Team members were allocated a set period to reflect on the situation and sketch over these copies or update the design or production notebooks.

Subsequently the team held a group critique of their findings to date and the more experienced members aided the novices in developing their design skills by requesting them to lead the discussion. They were asked to describe the project from the perspective of each project stakeholder and identify the key project deliverables and constraints. This process resulted in a few potential project risks being identified as well as some preliminary success and evaluation criteria.

A project brief was drafted based on the elements suggested in the interdisciplinary framework and the team leads presented it to OAF who agreed that the proposal provided a holistic understanding of the project and its context. OAF commented that they had underestimated the true scope of the project and the additional opportunities and barriers related to its success. These included the opportunity to incorporate the company's furniture into the landscape to promote its products and services and building a park-like space that could benefit the staff and local community. Barriers included potentially having to revisit the original building plan to optimize its integration with any proposed landscape design and deciding on the lifecycle of the landscape project. Ground Zero recommended that both parties take some time to reflect on the brief and reconvene at a set date in the future to go over the feedback and decide on the best course of action.

## CONCLUSION

Castells (2000) suggests that our society is becoming increasingly globalized. This globalization initiated by powerful information and communication technologies and the interconnection of global networks into a single entity – the Internet (p. 161). I suggest, therefore, that globalization has resulted in a myriad of different environments, systems, artifacts, disciplines, and users interconnecting in new ways. This melting pot generates even more ill-defined and complex design problems or opportunities and places greater social responsibility on disciplines charged with the design and manufacture of artifacts or knowledge that may be globally consumed.

Design-oriented disciplines are well equipped to meet these challenges provided they have a systematic approach in which to develop and apply their craft and a global community of practitioners who collectively contribute to an integrated corresponding body of knowledge. It is recognized that a true universal approach to design would need to further address the sociocultural differences at work within our increasingly globalized society. It is my belief that social networks and a collective and multidisciplinary approach to design hold promise in breaking down barriers to achieve this end.

The interdisciplinary design framework proposed in this document establishes a malleable foundation for all multidisciplinary practitioners engaged in the design process to apply and enhance. It leverages and facilitates the development of design skills and knowledge mutually in novice and expert practitioners and on both individual and team-based levels. Its strength comes from envisioning design as an interdisciplinary process and integrating instruments and processes from a range of disciplines to establish a system optimized for designing, managing, and learning within a constraints based project context. It reflects that design is best performed as an inclusive and participatory process, and the end result is the creation of an artifact valued by all in both form and function.

As a professional design practitioner the formulation of this interdisciplinary design framework has provided me with a set of instruments and processes to improve my own craft. My hope, however, is that the framework also functions as a catalyst for practitioners in other disciplines to recognize the merits in formulating a systematic and universal approach to design.

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# APPENDICES

## Appendix A: Project Management (PMBOK)[1] and User-Centered Design (UCD)[2] Framework Differences

Appendix A: ***PMBOK and UCD Framework Differences (Continued)***

| Differences | Notes |
|---|---|
| Risk management | One of the areas that project management addresses well but does not seem to be clearly reflected in the UCD framework is risk. The UCD framework also fails to identify the need to develop contingency plans in the advent of unforeseen risk events materializing. |
| Project focus | The UCD framework envisions a project primarily as a design problem that can be resolved creatively to meet the needs of customers, and in doing so benefit the sponsoring entity. The PMBOK framework envisions a project primarily as problem, opportunity, or business requirement linked to an organization's strategic plan. |
| Change | In the UCD framework a project plan and design requirements are defined at the onset of a project and the framework envisions change as a constructive force that shapes the final solution. However, the framework lacks a well-defined and integrated change management process. The PMBOK methodology tries to define the end outcome upfront, the path to that outcome, and then mitigate conditions that may potentially arise and jeopardize successfully staying that course. |
| Customer involvement | Both frameworks identify the importance of identifying customer requirements at the onset of a project and keeping them informed about the project's progress. UCD embeds ongoing participatory customer activities throughout all phases of its life cycle[3] and customer satisfaction is constantly attained and evaluated to inform the iterative design process. The PMBOK framework suggests the "project management team must identify the stakeholders, determine their requirements and expectations, and to the extent possible manage their influence in relation to the requirements to ensure a successful project" (PMI, 2004, p. 24). Furthermore, "unquantifiable expectations, such as customer satisfaction, are subjective and entail a high risk of being successfully accomplished" (PMI, 2004, p. 110). |
| Authority | The authority for project management decisions in the PMBOK framework resides solely with the project manger. The UCD framework encourages a much more team-based approach to project decision-making. |
| Life cycle parameters | Unlike traditional project management a UCD project does not necessarily end or become operationalized once the deliverables and objectives have been attained. Instead the project's design is viewed as reaching the end of an iterative cycle. The framework can accommodate ongoing evaluation processes in an effort to continually improve its usability and effectiveness. |

Appendix A: ***PMBOK and UCD Framework Differences***

| Differences | Notes |
|---|---|
| Stakeholder analysis | In PMBOK stakeholder analysis is described as a tool to help develop the scope definition, however, the framework does not describe apparatus to accomplish the analysis. UCD provides multiple tools (e.g., user profiles, user scenarios, usability metrics) within its framework to ensure stakeholder needs, wants, and expectations are documented. |
| Evaluation criteria | Both frameworks recognize that objectives need to be measurable, however, they deviate on what criteria should be used to establish a metrics for evaluation. Evaluation criteria for the PMBOK framework are primarily based on pre-defined project plans and baselines (e.g., scope, cost, time, quality). As work progresses these baselines are monitored and controlled for change. User-centered design establishes usability matrices, use-cases, and competitive benchmarks as the basis for evaluation. These metrics are used to assess prototypes and combined with user feedback inform design changes. |

[1] Based on an analysis of *A Guide to the Project Management Body of Knowledge*, Project Management Institute, 2004.

[2] Based on an analysis of *User-centered Design: An Integrated Approach*, by K., Vredenburg et al, 2002.

# APPENDIX B: PROJECT MANAGEMENT (PMBOK)[1] AND USER-CENTERED DESIGN (UCD)[2] FRAMEWORK SIMILARITIES

Appendix B: ***PMBOK and UCD Framework Similarities***

| Similarities | Notes |
|---|---|
| Initiating documents | Initial UCD planning documentation involves development of a basic plan that outlines the ”various data-gathering and design methods that will be performed, who will perform them and target dates for the activities” (Vredenburg et al, 2002, p. 118). The initial plan captures market, user, and functional requirements and relates these with the client’s currents portfolio. The primary objective is to attain data to inform the recruitment of sample users and conceptual development. There is no reference that the project may be terminated based on these findings. In contrast, initial PMBOK documents attempt to draft the scope of the project and relate the project to business objectives. The primary objective is to attain authorization to officially start the project. |
| Phase transitions | Both disciplines break complex projects into phases. UCD uses the transition between phases as an opportunity to solicit user feedback and further refine the design solution. The PMBOK framework often uses these as potential “ kill points” to potentially terminate the project based on project performance. |
| People | A common denominator for both UCD and project management frameworks is people. Projects in both disciplines can suffer from unclearly defined roles and a successful project is dependent upon the team working well collectively throughout the project life cycle. Individuals must feel their own contributions are respected and valued. |
| Environmental factors | Both UCD and project management frameworks are equally susceptible to the inherent social and cultural characteristics embedded within the project context. The PM framework identifies these as enterprise environmental factors. |
| Communication | In both disciplines communication is an essential element tied to a project’s success. Mutually each discipline reflects the need for ongoing and open communication between project stakeholders and the project team. Both disciplines must also wrestle with communication-related issues (e.g., language and culture barriers, geographically dispersed stakeholders). |

[1] Based on an analysis of *A Guide to the Project Management Body of Knowledge*, Project Management Institute, 2004.

[2] Based on an analysis of *User-centered Design: An Integrated Approach*, by K., Vredenburg et al, 2002.