The Design Process Review -- Pulling It All Together

Technological Design, June 9, 2016

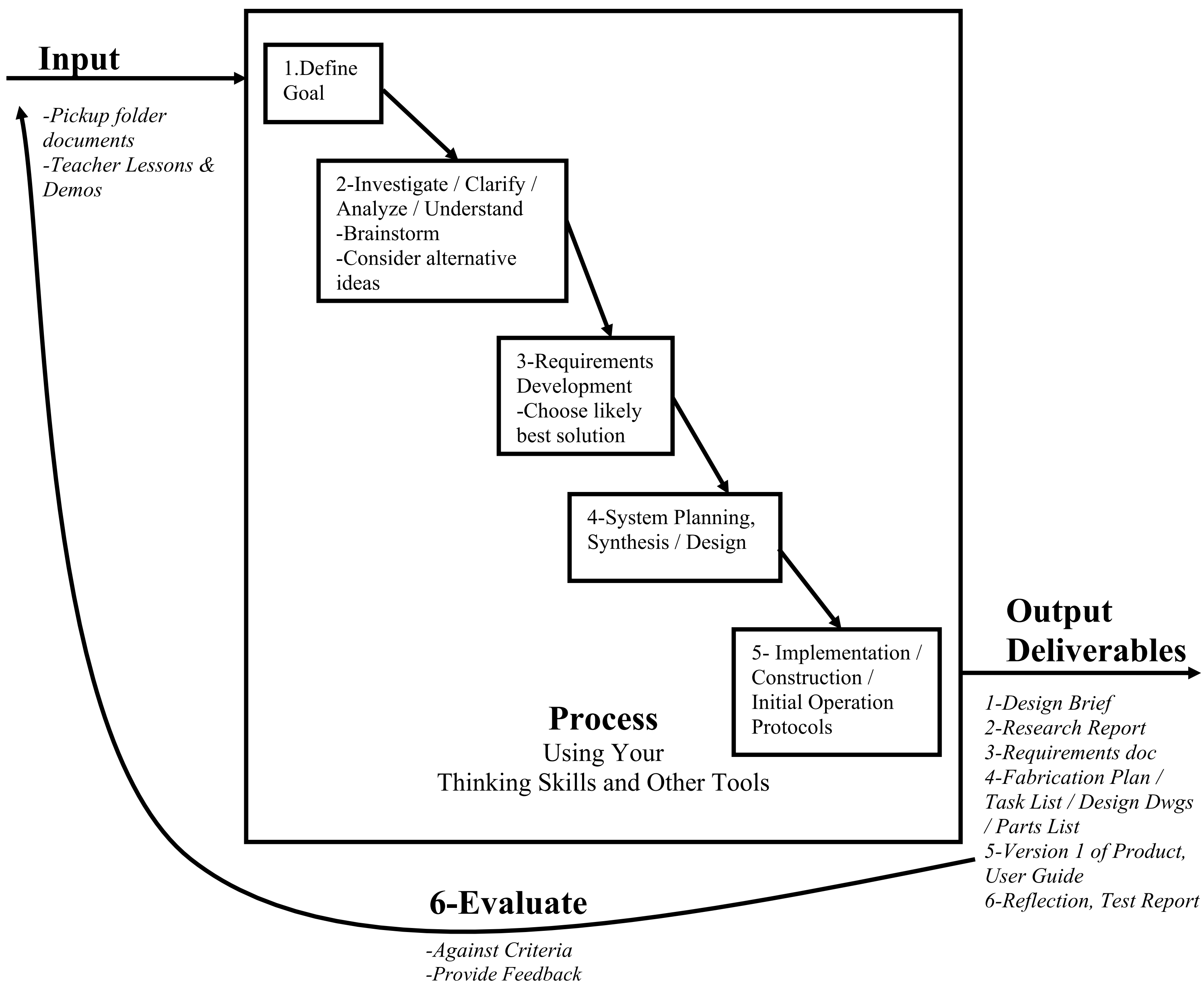
NOTE: This is not a review of the whole course. To review the course, do all of the Moodle quizzes again – thoughtfully. And there is a Design Process review quiz on http://thinkproblemsolving.org/ as well.

1 Design Process Review – Problem Solving Using Thinking Skills

Future professionals like you are in charge of designing the future. Understanding both the present and how we got here over time is key. The Design Process is a sub-set of the all-important "*Problem-Solving*" process. Critical thinking is required to understand the problem – commonly in the broader context of complex inter-related societal concerns. Creative thinking is required to generate a variety of alternative solutions as well as to fully develop the alternative which you feel is most likely to adequately solve the problem.

1.1 Stages of Design – An Overview

This diagram is an overview of the Design Process stages.



1.2 Design Process Outputs During Each Stage – Your Deliverables

On every design document, drawing, sketch, calculations or other file, you must show the:

- student name
- date
- version number
- project name
- Note: drawings must have the required information in a proper title block with units of measure

Note that your mark in the Thinking achievement category is made up largely of your work in Planning, Information-Processing and Problem-Solving. For guidance toward a better mark, refer to:

- Rubric_Information_Processing.doc and
- Written_Report_Rubric.doc (Communication achievement category).

The "acid test" for your design process documents in this course – ie your design portfolio – is this:

You should be so proud of your very well-organized and well-written design portfolio that you would enthusiastically show it to the human resources manager at a job interview.

Design Process Stage	Your Major Output Deliverable / Comments
Recognize the Problem or Opportunity -Understand the situation at least at a basic level -Develop focus	**Design Brief** -State your goal -State why your proposed product or process is so important
Research -Investigation, inquiry, gather data – looking at the bigger picture -Achieve deeper understanding of the problem including important possible sub-systems -Reverse engineer similar products that have "gone before" – explain the pros & cons of each -Best practices for designing, managing and building a product of this type -Brainstorming -Generate a set of alternative ideas (at least 2) including the key parameters for each (eg material, key dimension)	**Research Report** -Everything you need to know in order to achieve success with your design / build idea (product or process) -View your research portion as "*my efforts to become an almost-expert in this problem context*" -Sketches of the alternative ideas along with notes about key parameters (variables) – is the proposed value of each key parameter a pro or a con? -generally, every feature of an alternative solution idea is either a pro or a con -No final decisions are made in this document -The information in this document provides the foundation for your decision-making – this information would help you defend your decision-making in front of your boss or in a court of law

Deeper Analysis of the Problem
-Identify key requirements (criteria) to be met by your product for both construction (generally, what our product must look like) and performance (how our product must behave when operated or stressed)
-State Assumptions
	Version 1 of Product Requirements Document (PRD)
	-Generally at least one requirement for each of the 13 Fundamental Concepts of Technology
	-Several additional requirements of your own to clearly set your solution apart from the competition
	-If a particular industry standard(s) applies to your product type, state that compliance with the standard(s) is another requirement that you must meet
	-If carefully crafted (and to save you valuable time later), the:
	    -PRD can be the basis of a version 1 test plan
	    -PRD can be the basis of a version 1 user guide
	-Identify constraints (limitations) on what you can do or use in your solution (e.g. particular parts) or in the process to achieve your solution (e.g. particular tools that are available)

Design Process Stage	Your Major Output Deliverable / Comments
First Major Decisions to Make: Design-Related: -Carefully judge each alternative idea against the Requirements – use a "ranking" or "scoring" system if you wish -On a balance of features / functions and pros / cons, choose a solution option that is most likely to succeed -Find best features of your alternative ideas and consider them for the solution that you will ultimately pursue – a best solution may be a combination of ideas from your various alternatives	**Appendix to Version 2 of Product Requirements Document (PRD)** -Document your detailed justification for selecting this particular alternative idea as the one to pursue
Human Resources / Organization / Project Management: -Estimate the human effort required to get the overall job done -Identify skills that are required -Identify skill set "gaps" (what do you still need to learn and be able to do) -Estimate the time required -Estimate costs -Identify key milestones (with due dates for each)	**Project Management Plan / Task List Document** -assign team member accountability for each of the "sub-systems" within the product -assign Team Management Roles: Product, Project, Design, Fabrication, Quality and Communication managers comprise one team management model -spread-sheet or table in document – "*who does what by when*" (individual accountability for particular tasks with deadlines)
Plan / Design	-Translate the rather vague *Requirements* into very precise *Specifications*, as follows: -**CAD Drawings** (e.g. Inventor) – Represents "what we intend to build" -**Materials / Parts List** – Use a table in a word-processing document with columns for part / material name, part number, cost, supplier name / address, quantity (Parts list or Bill of Materials may also be on the design drawings) -**Cut List** – list of rectangular or cylindrical stock to be cut (which will be further processed and finished) – state quantity of each -**Fabrication Plan** – Numbered list of steps for making each part of your product -**Test Plan** – A numbered list of tests to perform on components or sub-systems or the entire product. Include "method of test" and the pass / fail criteria. (This begins with a good Requirements document) -**Assembly Plan** – Numbered list of steps required to assemble the various parts into the final product
Build / Implement / Post-Production Documents	-**Finished Product** version 1 -Final **As-Built Drawings** – "what we actually did build" -**Installation Instructions / Markings** (including cautions and warnings) -**User Guide** – "how to use our product" -**Theory of Operation** – "how our product works" (you probably don't want to give away your "secrets" though!) NOTE: A product without proper documentation is not a complete product!
Reflect / Evaluate	**Reflection** ("*Lessons Learned*") -Did your product meet all of your Requirements? If not, why not?

Design Process Stage	Your Major Output Deliverable / Comments
	-What went well -What went not so well? -Propose actions to take for an improved version 2 -What would you do differently in a future similar situation? -**Test Report** – including the results from all tests on parts, sub-systems and the assembled product

1.3 General Q and A – Design Process

1) **What is this course, Technological Design, "all about"? What is the "essence" of technological design?**
   a) 13 fundamental concepts of Technology – these help us understand "*just what is technology?*" (See keywords above shop window -- there are 3 missing, but you know what they are!)
   b) The Design Process -- purposefully and strategically solving a problem
   c) Applications within the Broadbased Technologies -- Communication, Transportation, Manufacturing, Computer Technology, Construction, Health / Personal Services, Hospitality / Tourism, Green Industries, Technological Design.

2) **The "broad-based technologies" comprise our model or simplification of what?**
   a) The "world of work"

3) **What is the purpose of learning about and using the Design Process?**
   a) All workers, whether users or creators or implementers of technology…:
      i) will use products, processes and procedures every day of their working lives
      ii) must be intelligent and careful consumers of technology
      iii) must be mindful of the limitations of any technology that they use
      iv) will -- or at least ***should*** -- participate in the preparation of new procedures or the improvement of existing procedures that they or their colleagues will use on the job
   b) Good procedures and processes are developed using the design process
   c) Procedures and processes are required in order to safely and effectively use technology
   d) So, if all workers should help develop procedures and processes, then all workers should have training in Technological Design and the design process.

4) **In our minds, how can we use the 13 Fundamental Concepts of Technology to help us solve a problem or take advantage of an opportunity?**
   a) Refer to the keywords posted on the wall. Refer also to the table of these 13 keywords in 13_Concepts_of_Technology_Pulley.doc in a "Pulley" context (or the similar Lighting document or the similar 1_1_S8-13Concepts_SuspBr_Feb1_16.doc)
   b) These 13 concepts of Technology provide an initial framework for setting basic requirements for any product or process. First use the translate and interpret thinking skills to "make more sense" of the stated scenario (the input that you receive from your customer, eg the "Situation").
   c) These 13 major concepts help us understand the nature of technology. These words can be imagined as the roots of a tree that allow us to grow our own model for understanding and applying concepts from science and tools from math in order to design and build technology.

5) **If, in general, outputs from one person on the design team are inputs to another person(s) on the design team, how will the team ever get their project finished?**
   a) The project must be planned carefully and thoroughly such that all members of the team will be working toward their goals in parallel.

b) At all times during the project, the entire team must know who is doing what by when. Task lists with clear deadlines are critical.
c) The design process is iterative. In other words, the action of passing outputs to another team member is happening constantly – throughout all stages of (and the smaller steps within) conception, planning, designing, fabricating, assembling, testing.
d) All team members must work toward their planning, designing and building goals in parallel – there is no "*waiting for so-and-so*". (Team members do not do their work "in series" with each other (to continue the electric circuit analogy)).
e) Each team member should be made accountable for the design and fabrication and testing of at least one sub-system of the product.

6) What is a reasonable way to break down a system into sub-systems?

a) One conceptual strategy to break a product down into sub-systems is to first look at the fundamental concepts of technology in logically-related groups in the context of the product and its purpose. For a vehicle, for example:
   i) The infrastructure / framework that holds all parts together – System, Structure, Material
   ii) Operation / Steering / Brakes – Control, Mechanism, Ergonomics, Function, Safety
   iii) The engine or source of the energy – Energy, Sustainability
b) Of course, there is a great deal of overlap between these sub-system "portions" of the product. Most of the 13 Concepts apply to all of the sub-systems.

1.4 Another View of Problem-Solving – The Big Picture in this Course ... and in Your Professional Future

1.4.1 Information about the World Around Us

We observe what we see, hear, feel, touch and taste. Some of these observations may be somewhat random or "in the moment" – and then we quickly forget about them. On the other hand, we can learn a great deal from our observations if we set our minds to it. This would typically involve having some kind of a plan or a set of strategies to use depending on the situation.

1.4.2 Analysis… Leads to Hypothesis (Type 3 Problem)

We can look at a system (physical, chemical, biological, social, economic etc.) and take into account what we already know that may be relevant to it. We can also take into account what other people have come to understand about this type of system, for example, theories, scientific "laws" and mathematical formulas. In the case of "laws" and formulas, we can be satisfied that the experts who derived them were "right" and their work verified by many others over the years. Originally a theory began as someone's hypothesis -- someone's idea of how and why something works. If a theory meets with a high enough level of consensus in the community of workers in which your problem generally lies **and** if your problem definition does not exceed the boundaries of applicability of that theory, **then** you can probably make some use of that theory in your system analysis (or at least try to). Regardless, analysis is our cognitive use of accepted theories, laws and formulas to come to some understanding of a system. This includes predicting how the system will behave in given situations. As such, analysis happens in our brains. This can generally be called our "hypothesis" in relation to that system. In general this analysis / inquiry process is a Type 3 Problem.

1.4.3 Experimentation and Measurement (Type 4 Problem)

Our cognitive analysis of a system should, hopefully, be a decent "first pass" at understanding it. We then turn to the actual system -- the physical situation or phenomena itself – devise or synthesize an experiment and then actually measure what is happening during and by the end of that experiment. If the measurements support your hypothesis, then you have achieved an additional level of Problem Solving – Type 4.

1.4.4 Building a Product (Type 5 Problem)

Only after clear problem identification, sufficient analysis, research, planning and careful and thorough synthesis of a design can you finally be confident in starting to build your product. Building anything other than a very simple prototype may cost a lot of money. Wasting time and money making mistakes that could have been avoided with better planning is a shame. Practice your building skills first. Knowledge of the tools, techniques, processes and fasteners is crucial to have before you start cutting and drilling. If you cannot actually make your product with the readily available tools, you should probably do some re-design.

When using any machine, here is the law:

1) Careful measurement
2) Careful understanding and setup of the machine
3) Carefully follow a sound and clear process

You can then use the machine safely to make multiple identical parts.

1.4.5 Derive Concepts from the Fundamentals – Develop Your Own Learning Strategies

Learning is much more powerful if you take charge of and develop your own learning strategies. As you have learned, there is much more to "Control" (for example) than the simple definition that you've seen. Even after studying an array of concepts that "fit under" Control, there are many concepts and ideas that derive from a consideration of "connections" with other ideas.

For example:

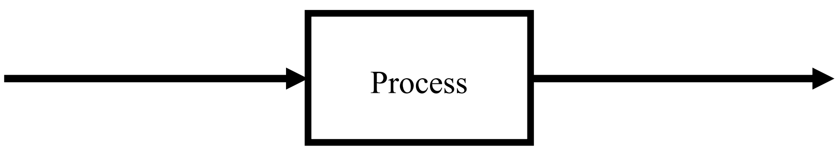
- **Failsafe**: If a device fails or malfunctions, it must automatically go to a "safe" state (ie cause no harm or damage)
    - Ever wonder why the "on" position of a switch lever is "up" (ie by convention)?
- **Intrinsically Safe**:
    - This could mean "*in and of itself, no matter how it is used or applied, the object or material must be "safe"*". Sounds almost impossible.
    - So this term is officially used in connection with environments which could contain explosive or combustible gases – the energy level of electrical equipment in that space must be so low that it could not possibly cause ignition of the gas.
- **Normally Open Contact**: When un-energized, the electrical switch or control is not allowing the movement of energy to a load. The electrical circuit is incomplete.
    - A spring is often used to hold the contact open.
    - **Note**: Gas valves to a gas-burning appliance are normally closed, ie not allowing the movement of gas energy to the burner. The gas circuit is incomplete.
- **Normally Closed Contact**: When un-energized, the electrical switch or control is allowing the movement of energy to a load

1.4.6 Look at the Inter-Relationships Between Systems – Think About Possible Unexpected Outputs

Another example of Unexpected Undesirable Outputs:

- The oil crisis came along in the 70s – oil resources are limited and the price of oil rose sharply
- "*Keep the heat in*" was the cry… "*seal up your house*"
- So codes were changed to seal new houses tightly against movement of air through the building envelope – and retrofit of old houses was also encouraged
- But oil-burning and gas-burning (becoming much more common in those days) appliances consume air for proper combustion of the fuel
- AND the air inside the house became stale
- "Sick House Syndrome" came upon us
- Mold was growing in the walls
- Let's let fresh air into the house – but by carefully controlling it in a safe and efficient way… designers got busy with ideas…

2 Re-Design this Visual Image in Your Own Way to Summarize Your Learning Model



Finally, as part of your exam review, do – and re-do -- all of the quizzes in the **Moodle** system at http://thinkproblemsolving.org.