HIERARCHY OF COGNITIVE DOMAIN LEARNING SKILLS TO GUIDE ACTIVITY DESIGN, CLASSROOM FACILITATION, AND CLASSROOM ASSESSMENT

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ABSTRACT

Development of a complex set of life-long learning skills in the cognitive, social, and affective domains is an important goal of engineering education. This is complicated by the reality that learning skill development transcends the temporal and spatial boundaries of isolated courses (SCANS 1991). This work responds to the need for a shared language to promote and reinforce learning skill development between courses and across the curriculum. The research question that motivated this work is whether greater specificity in learning skill definition than that prescribed by ABET Criteria 3 and 4 can be a useful tool for daily teaching/learning. This paper outlines the philosophy, organization, and application of a classification of learning skills within the cognitive domain. Over 90 distinct learning skills are grouped into skill clusters that fall within process areas aligned with Bloom's taxonomy. Learning skills within the classification apply from pre-college through graduate study. Candidate skills were inventoried from numerous literature sources and then validated, positioned, and refined through deliberations of an inter-disciplinary focus group. This paper includes a holistic rubric for defining, measuring, and elevating individual learning skills as well as discussion of how targeting specific skills can strengthen activity design, facilitation of learning, and classroom assessment.

NEED FOR LEARNING SKILL CLASSIFICATION

Educators committed to applying learning theory to classroom practice have long needed a shared language to use in discussing learning skill development. This is especially important among faculty engaged in general engineering classes, designers of active learning curricula, and members of accreditation committees striving to connect course-level learning outcomes with program-level outcomes. This paper introduces a framework for understanding learning skills in the cognitive domain that was initially proposed by a faculty focus group at Western Michigan University in 2002 and refined by the authors of this paper. This effort is part of a larger initiative by inter-disciplinary process educators across the country to establish a Classification of Learning Skills that provides a complete set of transferable learning skills in all four domains of human performance—cognitive, social, affective, and psychomotor (Beyerlein et al., 2003). The Classification of Learning Skills is predicated on four findings from pedagogical research.

1. Learning involves building a tapestry of conceptual, procedural, and meta-cognitive knowledge (Bransford et al., 2000).
2. Learning results in subject matter mastery, transferable long-term behaviors, and mature perspectives that can be both measured and elevated (Dewey, 1936).
3. Subject matter mastery (conceptual development in an area of knowledge, joined with fluency in applying it) can be planned, cultivated, and assessed using modern derivatives of Bloom's taxonomy (Anderson and Krathwohl, 2001).
4. Focusing on a small set of life skills at one time helps learners integrate these skills into their lives and elevate their daily performance (Covey, 1989).

The early developers of the Classification of Learning Skills began by recognizing that each discipline has its own special concepts, tools, language, and performance rubrics. However, they decided not to attempt a lengthy compilation of many overlapping skills. Instead, they chose to highlight a smaller listing of general cognitive skills that appear in multiple learning contexts (Krumsieg and Baehr, 2000).

The Classification of Learning Skills embodies a deliberately selective grouping of essential, yet discrete, learning skills. Each one is assigned only to the domain where it is most commonly applied; that placement is determined by deciding where it first becomes most critical to learning performance. While skills related to thinking processes are housed within the "*cognitive"* domain, those related to interpersonal processes can be found under the "*social*" domain. Similarly, skills related to attitude and emotional development are located in the "*affective"* domain, and those connected with body development and control, under the "*psychomotor"* domain.

The cognitive domain contains learning skills predominantly related to mental (thinking) processes. Learning processes in the cognitive domain include a hierarchy of skills involving processing information, constructing understanding, applying knowledge, solving problems, and conducting research. These processes enable performance at five different levels of learner knowledge, originally suggested by Bloom (1956). The cognitive domain contains several skill clusters that reinforce key aspects of each of these processes. Each cluster provides a complete, concise, and complementary listing of learning skills that are most critical for each process. Selective attention and sequential development of skills associated with lower level processes most efficiently leads to mastery of skills associated with higher level processes. As such, the list of cognitive domain learning skills contained in this module is a valuable reference for curriculum design, classroom observation, and assessment of learning outcomes.

ANATOMY OF A LEARNING SKILL

Learning skills are discrete entities that are embedded in everyday behavior and operate in conjunction with specialized knowledge. They can be consciously improved and refined. Once they are consciously recognized, the rate and effectiveness of overall learning increases. They can be identified at an early stage of a learner's development. No matter what the person's age or experience, learning skills can be improved to higher levels of performance through self-reflection, self-discipline, or guidance by a mentor. This growth in learning skill development is usually triggered by a learning challenge of some kind and is facilitated by actions built on a shared language between mentor and mentee. Finally, growth and development of a learning skill is sustained by quality feedback. These factors underlie the rubric for learning skill development presented in Table 1. Note how these change incrementally as one progresses from the rudimentary (Level 1) to the sophisticated (Level 5).

Table 1. Illustration of Cognitive Domain Competency Levels

Level of Competency	Description of Competency Level	Examples: (a) *Listening* (b) *Identifying assumptions*
Level 5 Transformative use	Skill is expanded and integrated with other skills for creative, productive application in novel contexts; inspires others to emulate use	(a) Purposefully listens and observes nuances and contextual details that deepen understanding of information and its application to a clearly stated need (b) Clearly articulates own and others' assumptions, enabling all to understand impacts on interpretations and conclusions on matters involving a wide variety of disciplines and perspectives
Level 4 Self-reflective use	Effective use of skill by learner; skill can be self-improved and adapted to unfamiliar contexts with occasional advice from a mentor	(a) Carefully listens and reflects on success to gain maximum understanding relevant to a specific need (b) Analyzes and recognizes relative impacts of assumptions made by self and others across a variety of disciplines and perspectives
Level 3 Consistent performance	Skill used routinely and effectively in multiple contexts through learner self-direction; not able to advance without external coaching	(a) Carefully listens to understand key points useful to address a specific need (b) Looks for impacts of assumptions by self and others in discussing interpretations and conclusions within areas of specialty
Level 2 Conscious use	Skill used knowingly, possibly proactively, by learner, but skill needs to be constantly challenged by a mentor	(a) Actively listens; identifies information thought important to general need (b) Aware of some assumptions underlying personal interpretations and conclusions, but often unaware of assumptions made by others
Level 1 Non-conscious use	Use of skill initiated by a prompt or influence external to the learner; unintended use of skill	(a) Passively listens; notes only information highlighted by others (b) Unaware when assumptions are made by self or others, often leading to erroneous conclusions

Two different learning skills from the cognitive domain are analyzed in Table 1—listening and identifying assumptions. These two examples illustrate how a specific skill used for basic processing of information and another skill used in constructing understanding can be demonstrated at very low levels (without conscious effort) and at very high levels (impressing and inspiring others). Monitoring learning skill proficiency along a common developmental continuum can be a tremendous motivator for learners. Similarly, recognizing which skills are underdeveloped in different learning situations can be used to plan interventions that accelerate desired cognitive development.

The Classification of Learning Skills is based on three assumptions:

1. By focusing on a small set of transferable, mutually exclusive learning skills, educators have an opportunity to build shared language about learning performance. Admittedly, there are many more learning skills than those featured in the Classification. In addition, the labels educators use to describe these often differ from one person to the next and from one discipline to the next. So, in order to work more productively across classroom and temporal boundaries, it is helpful to have a broadly recognized system for naming these skills.
2. A rubric for learning skill development helps educators and learners to understand and assess individual skills. However, it is important to keep in mind that learning skills are developed through practice and feedback; they cannot be elevated through conceptual knowledge alone.
3. A person only recognizes the need to learn a new learning skill when he or she cannot perform a task at a certain level—in other words, when the current skill level is less than that required for the task. If the learner perceives a task to be less challenging than his or her level of competence, they will not seek higher-level skills to do it.

ORGANIZATION OF THE COGNITIVE DOMAIN

The Cognitive Domain encompasses thinking skills that are independent of context and discipline. In contrast to other domains of learning, the cognitive domain addresses development that is individual rather than interpersonal, focuses on content rather than context, and is independent of emotion. The skill listing given in Figure 1 includes over 90 transferable learning skills relevant to undergraduate education, graduate education, and professional practice (Davis, 2003). These learning skills were worded in a manner intended to appeal to users in all academic disciplines. Enough specificity has been retained to insure that well-defined cognitive domain learning skills can be traced to most course and program learning outcomes.

Cognitive skill development is logically sequenced following the levels of Bloom's Taxonomy because learning skills from lower-level processes are embedded in learning skills associated with higher-level process (Anderson & Krathwohl, 2001). Five thinking processes therefore comprise the cognitive domain. These are: (1) **Processing Information**, (2) **Constructing Understanding**, (3) **Applying Knowledge**, (4) **Solving Problems**, and (5) **Conducting Research**. Critical thinking is purposely not identified with a single process area in the cognitive domain. Instead, critical thinking is considered a super-process that draws from all process areas in the cognitive domain during the creation of new knowledge or the improvement of existing knowledge. This viewpoint is consistent with principles of the National Council for Excellence in Critical Thinking (Paul, 2003).

Within each process area, learning skills are divided into clusters. Unlike the process areas, the skill cluster associated with a particular process area and the specific skills associated with each cluster do no follow a hierarchy. Skill clusters are given labels that communicate their role within each process area. For example, **Processing Information** includes the skill clusters collecting data, generating data, organizing data, retrieving data, and validating information. In Figure 1, processes are shown in bold, skill clusters are shown in bold italics, and learning skills as well as their definitions are shown without special formatting.

Processing Information

Collecting Data (from disorganized source)

Observing – seeing details in an environment/object
Listening – purposeful collection of aural data
Skimming – inventorying using key prompts
Memorizing – active mental storage of information
Recording – transcripting key information
Measuring – obtaining data using a predetermined scale

Retrieving Data (from organized source)

Recognizing patterns – perceiving consistent repetitive occurrences
Searching – locating information within a system
Recalling – retrieving from memory
Inventorying- retrieving from collective memory

Generating Data (to fill a void)

Predicting – forecasting from experience
Estimating – approximating from mathematical models
Experimenting – inferring from empirical study
Brainstorming – gathering ideas from previous experience

Validating Information (for value)

Testing perceptions – verifying based in interpretations
Validating sources – verifying based on credibility
Controlling errors – verifying based on procedures
Identifying inconsistency – detecting outliers/anomalies
Ensuring sufficiency – verifying data quantity/quality for context

Organizing Data (for future use)

Filtering – selecting data based on criteria
Outlining – identifying primary and subordinate groupings
Categorizing – associated data with established groups
Systematizing – designing an organizational framework

Constructing Understanding

Analyzing (characterizing individual parts)

Identifying similarities – recognizing common attributes
Identifying differences – recognizing distinguishing attributes
Identifying assumptions – examining preconceptions/biases
Inquiring – asking key questions
Exploring context – seeing relationship of parts to environment

Reasoning (revealing meaning)

Interpreting – bringing meaning for better understanding
Inferring – drawing conclusions from evidence and logic
Deducing – arriving at conclusions from general principles
Inducing – arriving at general principles by specific instances
Abstracting – describing essence of an idea, belief, or value

Synthesizing (creating from parts)

Joining – connecting identifiable parts
Integrating – combining parts into new whole
Summarizing – representing whole in a condensed statement
Contextualizing – connecting related parts to environment

Validating Understanding (for reliability)

Ensuring compatibility – testing consistency with prior knowledge
Thinking skeptically – testing against fundamental principles/schema
Validating completeness – checking for missing aspects
Bounding – recognizing limits of application of knowledge

Applying Knowledge

Performing with Knowledge (in real context)

Clarifying expectations – defining proficiency level
Strategizing – planning how to use knowledge
Using prior knowledge – integrating unprompted knowledge
Transferring – using ideas in a new context

Being Creative (in new contexts)

Challenging assumptions – exploring possibilities by relaxing constraints
Envisioning – imagining desired conditions
Linear thinking – generating new ideas from previous ideas
Divergent thinking – taking variety of positions to stimulate ideas
Transforming images – manipulating images to gain new insight
Lateral thinking – generating new ideas from associations

Modeling (in abstract context)

Analogizing – representing similar elements in new contexts
Exemplifying – showing by example
Simplifying – representing only primary features
Generalizing – transferring knowledge to multiple contexts
Quantifying – representing with numbers or equations
Diagramming – clarifying relationships through visual representation

Validating Results (for appropriateness)

Complying – comparing results with accepted standards
Benchmarking – comparing with results from best practice
Validating – using alternative methods to test results

Figure 1. Cognitive Domain Learning Skills (taken from Davis, 2003)

Solving Problems

Identifying the Problem (to establish focus)

Recognizing the problem – stating what is wrong or missing
Defining the problem – articulating a problem/need for solution
Identifying stakeholders – naming key players/audiences
Identifying constraints – recognizing limitations to solutions
Identifying issues – inventorying key stakeholder desires/concerns

Creating Solutions (for quality results)

Reusing solutions – adapting existing methods/results
Implementing – executing accepted solution practices
Choosing alternatives – selecting alternatives using criteria
Harmonizing solutions – fitting components into holistic solution

Structuring the Problem (to direct action)

Categorizing issues – grouping by underlying principles
Establishing requirements – articulating solution criteria
Subdividing – separating into sub-problems
Selecting tools – finding methods to facilitate solution

Improving Solutions (for greater impact)

Generalizing solutions – modifying for broader applicability
Ensuring robustness – modifying to fit more contexts
Analyzing risks – identifying external sources/impacts of error
Ensuring value – testing against requirements and constraints

Conducting Research

Formulating Research Questions (to guide inquiry)

Locating relevant literature – searching out seminal sources
Identifying missing knowledge – determining gaps in community understanding
Stating research questions – asking empirically answerable questions
Estimating research significance – forecasting value/impact to community
Writing measurable outcomes – specifying deliverables from research

Obtaining Evidence (to support research)

Designing experiments – specifying observable parameters and sampling
Selecting methods – determining research procedures
Extracting results – analyzing data to produce quality characterizations
Replicating results – duplicating experiments and findings

Discovering (to expand knowledge)

Testing hypotheses – discerning significant effects
Reasoning with theory – explaining data with accepted knowledge
Constructing theory – formulating new conceptual structures
Creating tools – adapting knowledge for practitioners

Validating Scholarship (for meaningful contribution)

Defending scholarship – presenting within disciplinary performance expectations
Responding to review – elevating scholarship from community input
Confirming prior work – adding credibility to body of knowledge
Judging scholarship – evaluating scholarship against criteria

Figure 1. Cognitive Domain Learning Skills – cont'd (taken from Davis, 2003)

SELECTION AND PLACEMENT OF LEARNING SKILLS

Each of the skill listings in the Classification was brainstormed, located, and validated by several cross-disciplinary teams consisting of a half-dozen faculty members working in a Pacific Crest faculty institute held at Western Michigan University. This typically began by writing short definitions of potential ("candidate") skills that were then placed within a process area and assigned key attributes.

To be considered for the classification, each learning skill was then tested against all of the following criteria:

- improvement in this skill leads to enhancement of learning performance,
- the skill is accessible and usable at all times,
- performance in this learning skill is unbounded (i.e., can be "grown" to progressively higher performance levels),

- the skill is transferable across disciplines and contexts,
- the skill applies to multiple forms of knowledge,
- the skill is a holistic element which can not be subdivided (i.e., it can not be either a label for a cluster of skills or a label for a process), and
- the skill is not a process consisting of multiple steps.

Once a skill passed all of the above tests, it was associated with a predominant domain and linked with the appropriate skill cluster. The skill cluster was then examined to ensure that it formed a compact, complete, and non-overlapping set—in other words, that nothing essential was left out or shared with another cluster. In this process, the following conditions had to be met:

- each of the skills is distinct and provides unique added value to the set;
- the skills and definitions are worded concisely, congruently, and completely; and
- the skills are not critical to learning performance at the next lower process level.

As "candidate" skills were considered for the Cognitive Domain Classification, definitions were refined so that they represented something unique and essential. This continued until all redundant learning skill components had been parsed out and nothing new remained. The skills and clusters were further refined by the authors subsequent to the initial focus group meeting.

USING THE COGNITIVE DOMAIN

By incorporating the transferable learning skills into instructional design and delivery, process educators have experimented with ways to make subject matter mastery more authentic (Hanson and Wolfskill, 2000). The Cognitive Domain offers a tool for highlighting and measuring well-defined subsets of learning skills traditionally associated with course content. Three examples are given in this section how learning skills in the Cognitive Domain can be used to enhance activity design, classroom facilitation, and classroom assessment.

Activity Design: Figure 2 portrays a learning activity that encourages design teams at any level to explore a wider variety of methods for creative thinking in pursuing innovative design solutions. Teams are first asked to list as many methods as they can to generate creative ideas for design solutions. Next they are given the listing of Cognitive Domain learning skills and asked to analyze the skills under the creativity cluster. They are then challenged to apply each of the creative thinking skills to generate one or more ideas for the problem of fastening two pieces of paper together. Table 2 gives a result from this task. Next, students are asked to select a difficult area of their design project calling for creativity and to apply each of the creative thinking skills to generate a design alternative. Finally, they are asked to discuss how they might systematically add creativity to their design team efforts in order to produce a higher quality design solution. In subsequent project meetings teams are encouraged to use the learning skills from the creativity cluster as prompts to improve brainstorming and decision-making. By introducing a common language for discussing and self-assessing creativity skills, design teams can better collaborate in elevating these skills. Through consciously challenging assumptions, envisioning, linear thinking, divergent thinking, transforming images, and lateral thinking, design teams are also likely to surface more and better ideas for their projects.

Developing Skills for Increased Creativity

Outstanding design solutions have a discernable element of creativity. Design teams with broad skills in creativity have resources to tap for generating more innovative solutions that have a greater likelihood of meeting customer needs. In this activity your team will identify, explore, and enhance several skills for creative thinking. You will be given a language for discussing and reflecting on elements of creativity that can benefit idea generation in your design projects.

Objective:

Explore a variety of methods for creative thinking to expand your team's tool set for generating innovative design solutions.

Criteria for Success:

- Teams are able to recognize and utilize new skills for creating ideas.
- Teams agree on an action plan for improving productivity in future idea generation.

Tasks:

1. Assign roles to support this activity. (one minute)
2. Without looking ahead, list as many methods as you can to generate creative ideas for design solutions. (four minutes)
3. Review the Cognitive Domain skills for creative thinking. Use each skill to create a second idea for attaching two sheets of paper together. (ten minutes)
4. In an area of your project calling for creativity, apply each of the creativity skills to generate one or more new ideas. Record these and be prepared to report on these at the end of the activity. (ten minutes)
5. Identify three ways to systematically add creativity to your team's efforts. (five minutes)

Deliverables:

1. Team Report presents:
   - Ideas generated in response to a project need
   - Strategy to improve team creativity
2. Team Reflector reports:
   - A team strength for this activity
   - An area in which the team can improve
   - An insight about creativity

Figure 2. Creative Thinking Activity

Table 2. Results from Creative Thinking Activity

Cognitive Learning Skill (related to creativity)	Prompt	Idea
Challenging Assumptions	Remove assumption: papers need not be in same plane	Slit both pieces and insert into one another in shape of "T"
Envisioning	Ideal conditions: No extra volume required by fastener	Use static charges to hold pieces together
Linear Thinking	Previous idea: staple	Rivet together
Divergent Thinking	Opposite position: hold papers apart	Slide object between the pieces; slide another object outside both pieces
Transforming Images	Image: papers floating through air while together	Use flow of air between papers to draw them together
Lateral Thinking	Illogical association: paper heavy enough that gravity holds top sheet down	Add substance to paper to increase its weight

Classroom Facilitation: One of the more valuable processes to help faculty improve their performance in the classroom is peer coaching. The peer coaching process has three stages. First, a faculty member desiring to improve some aspect of their classroom performance, requests another faculty member to give feedback on what they see. There is a dialog prior to the classroom session where the focus for peer coaching is explicitly identified. Learning skills can be used to add specificity to this assignment. Second, the peer coach spends time in class collecting data on student performance and instructor interactions along with analysis of strengths, improvements, and insights. The strengths should describe why a particular behavior is valuable and hypothesize what caused this behavior. The improvements should offer suggestions for implementation as well as context in which these are appropriate. The insights should be transferable across disciplines and teaching environments. Third, the peer coach sits down with the instructor after the classroom session to give feedback on what they saw and to answer clarifying questions. While the primary purpose of peer coaching is helping the instructor improve their facilitation skills, a second benefit is helping the peer coach see ways in which to improve their own classroom performance.

The peer coaching form shown in Figure 3 is intended to structure class observation by a peer coach and to capture data for fruitful post-class discussion. It begins with a forecast of key learning skills for a particular lesson that has well-defined content. It focuses on just a few skills and seeks to collect insights on how well students are using these skills and how effectively the instructor intervenes on these skills in the process of achieving content objectives. Subsequent questions in Figure 3 are intended to stimulate and enrich post-class dialogue. Note that these questions can be used to explore facilitator performance in the social and affective domains as well as the cognitive domain.

Peer Coaching Form

Class/Period: Date:

Instructor/Assessee: Peer/Assessor:

1. Which three learning skills does the instructor consider most critical to the success of this activity? Why are these particular skills important? What difficulties are students likely to encounter because of skill deficiencies?

2. How were students made aware of targeted learning skills during activity start-up?

3. Which three learning skills were most highly developed by the student teams you observed? What circumstances surrounded the application of each skill?

4. What other learning skills could the facilitator have focused on during the activity? (i.e. lost opportunities)

5. How effectively did the facilitator use peer and self-assessment to improve awareness and use of key learning skills?

6. Which two interventions by the facilitator were most effective in helping students improve their skills and how were these done? What improvements would you recommend?

Figure 3. Peer Coaching Report on Learning Skills

Classroom Assessment: In teaching a process, such as engineering design, it is instructive to identify critical skills at each stage of the process for students to address in elevating their performance. What skills are critical in the process can change with students' experience and developmental level. Table 3 portrays a comparison of learning skills associated with engineering design in two contexts that represent different levels of development: (a) freshman engineering design and (b) senior capstone engineering design. Skills are grouped around seven major elements of the design process described on the Transferable Integrated Design Engineering Education (TIDEE) web site: www.tidee.cea.wsu.edu. Elements of this process listed in column 1 include: information gathering, problem definition, idea generation, evaluation and decision making, implementation, and process improvement.

The second column of Table 3 relates to the PET bottle activity that is used in an introduction to engineering class. Freshman design teams are asked to propose uses for empty PET bottles that maximize use of material while at the same time creating a valuable consumer product. Cluster labels from the cognitive domain are shown in bold italic. Likewise, italics identify cognitive domain learning skills. Note that there are some additional learning skills outside the cognitive domain that are identified at the bottom of the table.

The third column in Table 3 relates to a design review for an industry-sponsored senior design project. Skills in this column are more complex than those associated with the freshman class because senior students are assumed to be at a higher level of development. The comparison of skills in these two columns serves as a prompt to instructors and students to develop and expect demonstration of higher level skills in the senior course.

The skills listed in Table 3 can serve as a guide for classroom assessments in design courses. It is not necessary to address all of the enumerated skills in a single performance assessment, only those skills that are most prominent or most deficient. By focusing on specific skills within a process, like design, students can become more metacognitive about their use of these skills and can better visualize strategies for strengthening the design process based on improved performance in a manageable set of skills.

CONCLUSIONS

The Cognitive Domain is part of a learning skill classification that addresses cognitive, affective, social, and physical dimensions of learning. This hierarchy of learning skills is a useful tool for facilitating learners' growth and development, measuring and documenting growth, assessing self and peer performance, and improving instructional design for skill development. It aligns with accepted learning theories that consider both learning skill development and subject-matter mastery. It is built around a common model for learning skill development shown in Figure 1. The Cognitive Domain skill definitions stimulate new kinds of questions related to the identification and understanding of learning skills. These include measurement of learners' growth and development, the role of faculty in mentoring, and the importance of skill development to learning (as opposed to exclusively focusing on content mastery.)

Teachers and learners need to understand the hierarchy of processes and skills within the Cognitive Domain so they appreciate prerequisite skills for learning as well as the way these skills need to be transformed to master more complicated elements of discipline-specific concept inventories. Development of learning skills should never be taken for granted in teaching or learning new content. Skills associated with lower-level processes should be introduced in foundational courses and elevated in intermediate-level coursework. Skills associated with higher-level processes should be thoughtfully introduced and reinforced in upper-division courses. Methodically invoking key learning skills from different process areas and clusters across the cognitive domain also provides a method for infusing richness in course activities while strengthening life-long learning skills. The Cognitive Domain presented here also serves to remind us that improved cognitive domain performance is always possible, no matter what one's state of learning skill development.

Table 3. Comparison of Skills for Different Development Levels in Engineering Design

Elements of Design	Skills for Freshman Design	Skills for Senior Design
Information Gathering	***Collecting Data*** *Observing* *Listening* *Recording* ***Analyzing*** *Inquiring* *Exploring context*	***Identifying the Problem*** *Identifying stakeholders* *Recognizing the problem* ***Analyzing*** *Exploring context* *Identifying assumptions* ***Validating Information*** *Validating sources* *Identifying inconsistency*
Problem Definition	***Identifying the Problem*** *Identifying assumptions* *Establishing requirements* ***Synthesizing*** *Summarizing* *Integrating*	***Modeling*** *Quantifying* *Diagramming* ***Identifying the Problem*** *Identifying constraints* *Identifying issues* ***Structuring the Problem*** *Establishing requirements* *Categorizing issues*
Idea Generation	***Generating Data*** *Brainstorming* *Experimenting* ***Being Creative*** *Challenging assumptions* *Divergent thinking* *Lateral thinking*	***Formulating Research Questions*** *Locating relevant literature* *Identifying missing knowledge* ***Being Creative*** *Envisioning* *Challenging assumptions*
Evaluation and Decision Making	***Organizing Data*** *Systematizing* *Categorizing* ***Modeling*** *Exemplifying* *Simplifying*	***Obtaining Evidence*** *Selecting methods* *Designing experiments* ***Creating Solutions*** *Reusing solutions* *Choosing alternatives* *Harmonizing solutions*
Implementation	***Performing with Knowledge*** *Clarifying expectations* *Strategizing* ***Reasoning*** *Inferring* *Deducing*	***Structuring the Problem*** *Subdividing* *Selecting tools* ***Discovering*** *Reasoning with theory* *Testing hypotheses*
Process Improvement	***Validating Information*** *Testing perceptions* *Controlling errors* ***Validating Understanding*** *Ensuring compatibility* *Validating completeness* *Bounding*	***Validating Results*** *Complying* *Benchmarking* ***Improving solutions*** *Ensuring robustness* *Analyzing risks* *Ensuring value*
Team Dynamics	Respecting other's ideas Playing assigned roles Committing to hard work Achieving consensus Recording activity	Committing to team goals Accepting accountability Supporting team members Client Communication Documenting Progress

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