Developing Sound Problem Statements for Course and Capstone Projects

Dr. Arif Sirinterlikci Ph.D., CMfgE, CPEM, Robert Morris University

Dr. Arif Sirinterlikci, Ph.D., CMfgE, CPEM is a University Professor of Industrial and Manufacturing Engineering in the School of Engineering and Science (SES) at Robert Morris University (RMU). He holds BS/MS degrees (both in Mechanical Engineering) from Istanbul Technical University in Turkey, and his Ph.D. is in Industrial and Systems Engineering from the Ohio State University. He was involved in the ASEE Organization in the years between 2003 to 2011 as a Manufacturing Division Officer, also serving as the division's Chair between 2010 -2011. He is also a member of Mechanical and Industrial Engineering Divisions along with the College and Industry Partnership (CIPD) Division. He is a co-author of the textbook titled, A Comprehensive Approach to Digital Manufacturing, which was originally published in April 2023.

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Abstract

This paper emphasizes sound problem statement development practices for engineering course and capstone projects. The author enforces these practices with the aim of his student teams achieving better project outcomes, also aiding in improved project documentation and its presentation. These practices are employed in a product design and development exercise within a junior/senior level manufacturing engineering elective as well as an interdisciplinary capstone course. These practices include the workflow of developing need statements, addressed by responsive goals and objectives, and constrained by defining specifications. Objective and function tree structures are employed before the assignment of technical, social, and economic constraints, consideration of environmental and safety concerns along with the legal framework including the Intellectual Property (IP) Laws. Software dominant projects employ a slightly different approach with Software Requirements Specifications (SRS) development.

This paper exhibits the details of the problem statement development practices with examples, taken from the author's experiences spanning over two decades of project work, including the challenges, and the impact of problem statement development leading to best and worst cases. Effective use of engineering codes and standards is also covered as a part of this effort. This paper concludes with the role of design thinking and human- and ego-centric approaches along with design tools like Quality Function Deployment (QFD) and Failure Modes and Effects Analysis (FMAE).

Introduction

This paper *emphasizes sound problem statement development practices for engineering course and capstone projects, by presenting multiple different approaches that are followed in engineering education*. The author enforces these practices with the aim of his student teams achieving better project outcomes, also aiding in improved project documentation and its presentation. These practices are employed in a product design and development exercise within a junior/senior level manufacturing engineering elective as well as an interdisciplinary senior capstone course. The paper includes the ABET's problem solving requirements along with the relevant terminology on problem formulation, including terms such as complexity and constraints.

After a comprehensive literature review, the author presents the *traditional product design method* he follows in sound and clear stages with different examples (e.g. coffee maker, washing machine, and a can crusher), along with a case of a solar distiller design he employs to convey his message to his students. In the discussion section following the previous presentation, *Design Thinking* approach's *Point of View Statement* is given and contrasted with that of the traditional method. The paper is concluded with further discussion and analysis that also includes roles of tools such as Quality Function Deployment (QFD) and Failure Modes and Effect Analysis (FMEA).

Literature Review

A literature review was conducted through the ASEE's Peer Paper Repository System employing the key words "problem and needs statements" separately. Even though many papers were found to include these keywords in their abstracts, only a small number of papers are deemed to be valuable for this study, as presented below in this section:

Dixon [1] explored the challenges and inconsistencies students face when writing problem statements for senior capstone design projects. According to the author, there is no clear industry or academic standard for what a problem statement must include. The author also sees that students often mistake "design objectives" (what they want to achieve) for a "problem statement" (the fundamental issue they are solving), and literature in 2012 lacked specific rubrics or standardized methods for faculty to evaluate the quality of these statements. The study included a qualitative exploration of how problem statements are written and assessed. The study's goal was to create a shared understanding between faculty and students, ensuring that both parties agree on what constitutes a high-quality problem statement within a two-semester-long capstone effort.

Loweth et al. demonstrates that [2], the way that a design problem is defined establishes the project's direction and specifies a range of acceptable solutions. A key aspect of the problem definition process is the development of "needs statements" that concisely articulate the design problem and indicate what change in outcome is necessary for solving the problem. This study examines how engineering students convert stakeholder data obtained during interviews and observations into needs statements during a co-curricular project in rural South America. After training, students successfully identified two core principles: balancing specificity with openness and avoiding "pre-solving" by embedding solutions into the problem. While students could explain these principles, they still struggled to apply them when writing their own statements. They also completely failed to incorporate measurable outcome criteria into their statements. However, their understanding of the process improved and became more specific after the "the-field" experience. At the conclusion of their efforts, the authors suggest employing two teaching strategies: providing students with multiple comparative examples of both "good" and "bad" needs statements to help them recognize quality, and using a visualization tool to help them navigate different levels of abstraction and find the right scope for their project via "why-how laddering", allowing teams progress between "high-level abstract goals" and "low-level concrete actions (objectives)".

Pagano and Shehab [3] outline a workshop focused on the systematic construction of problem statements for engineering course design projects, based on instructor-led strategies. According to them, instructors struggle to create projects that are "real-world" and human-centered, yet structured enough to ensure students learn specific concepts. They also assert that projects often fail to facilitate "joint problem spaces," where team members must truly co-construct knowledge rather than just "dividing and conquering" their individual tasks. The workshop leads to a backwards-mapping sequence to writing problem statements for the instructors:

1. Identification of Learning Outcomes: Starting with the specific engineering concepts and skills the students must learn.
2. Scenario Mapping: Working backward to find a realistic, human-centered scenario where those specific skills are the only way to solve the associated problem.
3. Systematic Scoping: Using a series of questions to define the "design space" so it guides students without giving away the solution.
4. Embedding Prompts: Intentionally place prompts within the problem statement that require collaboration, forcing students to build a shared understanding of the problem.

The study by Silk et al. [4] introduces a framework for writing problem statements based on "Kirton's Adaption-Innovation (A-I) Theory." The core idea of this approach is that the way a problem is "framed" can mentally "steer" students toward either refining existing ideas or inventing radical new ones. The authors categorize cognitive styles into two types: "adaptors", who prefer working within existing structures and consensus, and they like "doing things better ", as well as "innovators", who prefer less structure and are willing to challenge consensus, and they like "doing things differently." The study suggests that by adjusting constraints and criteria, an instructor can trigger specific ideation behaviors regardless of a student's natural cognitive style, as indicated in Table 1:

Table 1. Instructor triggered specific ideation behaviors [4]

Framing Type	Focus	Strategy used in the Statement
Adaptive	Evolution	High specification: well-constrained; goals focus on improving or building upon existing solutions.
Innovative	Revolution	Low specification; minimal constraints; goals explicitly encourage "radically different" or rule-breaking solutions.
Neutral	Balanced	A standard problem statement without a specific lean toward one cognitive style given above.

Another study, by Pyrialakou et al. [5], shifts the focus toward topic selection and the use of external databases to help students find meaningful research problems to solve. Identifying and selecting a research topic is the hardest part of a project for U.S. college students, Blank Page Struggle. While the Internet offers "vast" info, students are often paralyzed by the volume of information and a lack of time, Paradox of Choice. Usually, students either pick a random interest or are handed a topic by the instructor, missing the chance to learn how to identify real-world needs, Educational Gap. The authors use the "Transportation Research Board's (TRB) Research Needs Statements (RNS)" database as an educational tool. This is a database where industry professionals list actual unsolved problems. By analyzing student cases at Purdue University, the study looked at the "interplay" between: student interests, selected RNS, how the students turned that need into a class project, as well as the student experience.

The study, by FYI Team Members and Cloete, [6] describes a holistic, curriculum-wide approach to problem-solving, moving it from a single assignment to a foundational philosophy, Problem Solving as a "Way of Thinking". Rather than treating "Critical Thinking & Problem Solving" as a standalone elective, this initiative makes it the pedagogical hub for the entire first-year experience, following "integration" not "isolation." The curriculum is rearranged to support "heuristics" strategies or mental shortcuts that help students approach open-ended, complex problems systematically. The implementation can be seen as the "FYI" Model due to:

- Collaborative Teaching: Faculty members from different technical courses work together to ensure their assignments align with the critical thinking course.
- Rearranging the Sequencing: While keeping the original course goals intact, the *timing* and *scope* of assignments are adjusted across all five first-term courses to present a unified problem-solving methodology.
- Immediate Application: Students learn a critical thinking theory in one class and immediately apply it to technical problems in their electronics course.

Lumsdaine [7] provides the "proof of concept" for why the previous strategies matter. The study focuses on the execution phase of capstone design and how specific team-building and process-driven interventions lead to superior outcomes. He proposes the "Michigan Tech" Model as a guide to success:

- Cognitive Team Building: Teams were not formed randomly; the authors used the “Herrmann Brain Dominance Instrument (HBDI)” to ensure existence of thinking styles (analytical, organized, interpersonal, and imaginative) within each group.
- The "Forced" Process: Students were explicitly prevented from "moving ahead" with their first idea. Instead, they were required to follow a 12-step design process and a formal Creative Problem Solving (CPS) framework.
- Shift in Focus: The first semester focused on "soft" but critical skills (team dynamics, conflict resolution, thinking modes), while the second focused on technical "Design for X" (manufacturing, quality, Six Sigma).

Resulting effort led to total elimination of dysfunction through “quality” over “speed”. By forcing the students to slow down and use a broader range of thinking modes, the final solutions were objectively better than their initial reactions. In a cohort of 121 students, none of the 24 teams were dysfunctional, a rare occurrence in capstone classes, satisfying every industrial sponsor [7].

The study by Hart et al. [8] introduces a technique called "Problem Set Zero" (PS0), which addresses the issue of knowledge retention and the "surface learning" trap in engineering education. This paper is not directly relevant to subject of this paper. However, it focuses on “lack of student readiness” for course and capstone projects. Thus, it is very important to the subject of this paper due to:

- The Recall Trap: Students often master short-term memory and "recall" to pass exams (surface learning) but fail to retain these knowledge and skills for later use (deep learning).
- Prerequisite Decay: Even if a student passes a prerequisite course, they often arrive at the next course (or the capstone) unable to apply fundamental skills.
- The Re-teaching Loop: Instructors find themselves wasting time re-teaching basic concepts from previous semesters because students have "familiarity" but not "mastery."

The faculty at the U.S. Military Academy implemented a mandatory process at the start of new courses to respond to surface learning:

- The "Zero" Concept: This assignment evaluates material from *prior* courses that is essential for the *current* course.
- Mastery Requirement: Students must prove they have mastered this prerequisite material before they are allowed to move on to "Problem Set One" (PS1 - the actual course content).

- The Goal: To ensure the "baseline of knowledge" is solid, preventing the project or course from stalling due to a lack of fundamental knowledge and technical skills.

In summary, based on the eight studies provided above, we can now assemble a big picture relating to problem solving in course and capstone projects. The “Big Picture” includes points that lie beyond the formation of problem statements as defined below, including curriculum and readiness of the students, determination of the problem and team formation, and assessment methodology, Table 2.

Table 2. The Big Picture

Curriculum & Readiness	• Strategy: Implement a "Problem Solving Way of Thinking" from Freshman year [6]. • Quality Control: Use "Problem Set Zero" to ensure students haven't just "surface learned" the prerequisites [8].
Sourcing & Team Formation	• The Problem: Use professional databases (like the TRB RNS) to find real-world, high-value project topics rather than random student guesses [5]. • The Team: Form teams based on cognitive diversity (HBDI) to ensure a balance of analytical and creative thinkers [7].
Problem Statement	• Definition: Focus on "Needs" (the what/why) rather than "Objectives" (the how) to avoid pre-solving the problem [2]. • Framing: Use "Adaptive" or "Innovative" framing to trigger the specific type of creativity required for the project [4]. • Pedagogy: "Backwards-design" the statement to include prompts that force a joint problem space, making solo work impossible [3].
Evaluation (Assessment)	• The Gap: Recognize that we currently lack standardized rubrics to judge if a problem statement is "thorough" [1]. • The Solution: Use tools like Why-How Laddering to help students and faculty align on the correct level of specificity [2].

"The Problem Statement is not just a description of a task; it is also a designed pedagogical instrument." The Big Picture reveals that a successful capstone or a course project doesn't happen at random. It requires a triple-alignment of the following factors [9]:

1. Cognitive Alignment: Matching the student’s thinking style to the problem’s framing.
2. Structural Alignment: Forcing collaboration through the way the problem is written.
3. Technical Alignment: Ensuring "Deep Learning" of prerequisites before the project even begins.

When these factors are aligned, one moves from "dysfunctional, mediocre projects" to "high-quality, professional-grade solutions." [9] To understand what other resources we have in structuring the problem statements as well as problem solving, the author reviews the relevant requirements of ABET (Accreditation Board for Engineering and Technology) in the next section of this paper.

ABET’s Problem Solving Requirements

ABET views problem statement generation (often referred to in their documentation as problem formulation or problem identification) as a foundational competency for any engineering graduate. It is not just a preliminary step but a core part of the "Engineering Design" and

"Problem Solving" outcomes that programs must assess for their accreditation. Following section describes its relation to ABET's current requirements for the 2024-2025 and 2025-2026 cycles:

1. The Core Requirement - Student Outcome 1: ABET's General Criterion 3, Student Outcome 1, requires that students demonstrate [10]: "An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics." According to ABET, "formulation" is the act of taking a complex, real-world situation and translating it into a structured problem statement. To meet this outcome, students must:
- Identify that a problem exists (occasionally from "ill-defined" or "open-ended" scenarios).
- Formulate the technical requirements, "generating the problem statement" by defining the scope, variables, and mathematical or scientific principles needed to solve it.

2. Integration with Engineering Design - Student Outcome 2: Problem statement generation is also a mandatory component of the Engineering Design process ("An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors."). ABET defines design as a "decision-making process" that must include [10][11]:
- Establishment of Objectives and Criteria: You cannot have a design without a clearly defined statement of what you are trying to accomplish.
- Identification of Constraints: ABET requires problem statements to include "realistic constraints" such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability factors.

3. "Complex" vs. "Well-Defined" Problems [12]: ABET distinguishes between simple textbook exercises and the types of problems graduates should be able to define. For a problem statement to meet ABET standards for a bachelor's program, it should ideally be complex, meaning that it involves wide-ranging or conflicting technical issues, has no obvious solution ("open-ended"), and requires the use of "first principles" (fundamental mathematics/science) rather than just looking up a manual.
4. ABET Evaluation: When ABET PEVs visit a university, they look for "Performance Indicators" in student work including Senior Design reports [13][14] to see the evidence of ability to [15]: ul extract a problem statement from a client need, define the "end state" or what successful outcome looks like, and present all relevant assumptions and constraints clearly before attempting a solution.

Table 3. ABET's view on Problem Formulation [10][13]

Element	ABET Requirement
Terminology	Often called Identification and Formulation.
Complexity	Must involve "complex" or "broadly-defined" problems, not just plug-and-chug.
Constraints	Must include specific factors (economic, ethical, etc.) in the statement.
Outcome	Students must prove they can do this independently before graduating.

The Approach

The practice followed in the author's classes and documented in this study (Figure 1) is based on the workflow of developing need statements, addressed by responsive goals and objectives, and constrained by defining specifications [16]. This approach also agrees with most of the literature

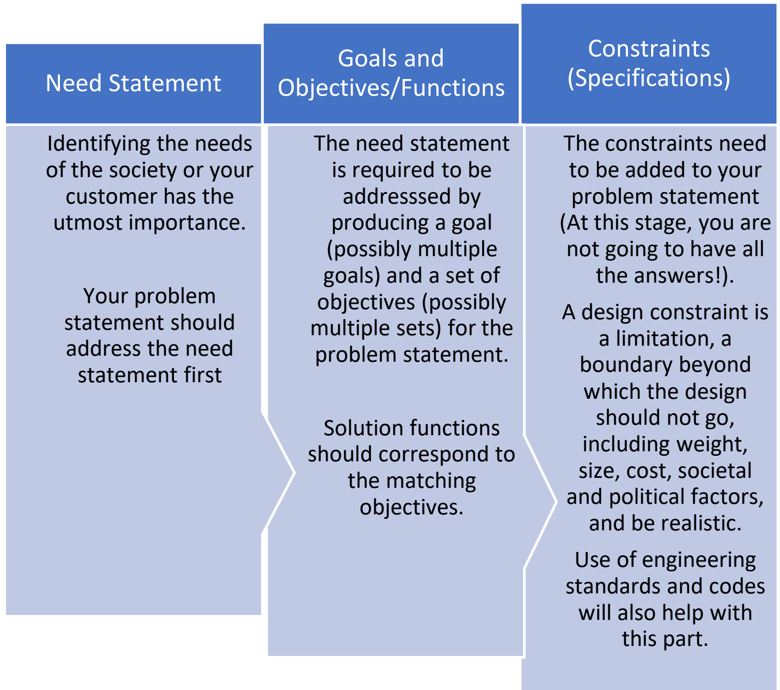

Figure 1. Ealy problem-solving practice workflow given to the students

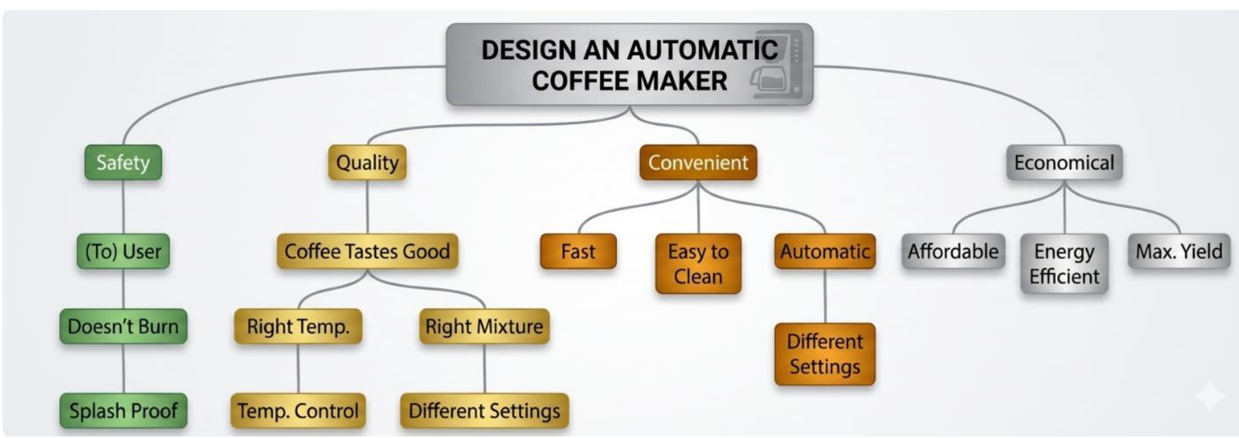

Figure 2. Objectives tree for an automatic coffee maker [16]

presented in the earlier sections of this paper, embodying them in an integrated fashion. It also is ABET compliant. In addition, the teams involved in the author's effort are multidisciplinary. However, this is slightly different than employing HBDI in making project the teams as mentioned earlier.

Students in the author's classes are presented with the following examples including developing a coffee making machine. It starts with the need statement of "Professionals do have very limited times in the mornings for breakfast. Thus, they could use a coffee making machine." [16]

The next step is the introduction of goals and objectives. The goal of addressing the "morning coffee making need for professionals" leads to an automatic solution. Thus, the goal of designing an automatic coffee maker and its associated objectives are given above in Figure 2's objective tree. As the students understand the objectives (safety, quality, convenience, economy and their details) supporting this goal, the author introduces the differentiation between goals and objectives, as sketched in Table 4 below.

Table 4. Goals versus Objectives [17]

Basis of Comparison	Goals	Objectives
Definition	Broad, primary outcomes toward which effort is directed.	Specific, measurable actions to be taken to achieve the goal.
Scope	General and broad; the "big picture."	Narrow and specific; the "individual steps."
Specificity	Abstract and qualitative.	Concrete and quantitative.
Time Frame	Usually long-term (months to years).	Usually short-term to medium-term.
Measurement	Hard to measure directly; subjective.	Easy to measure via specific metrics/data.
Relationship	The destination or end-state.	The milestones or roadmap to get there.

A function tree (Figure 3) is presented to the students next. These trees indicate the relationship between the objectives and the functions that help accomplish them. After the presentation of these trees, students are exposed to the constraints in the form of technical, social, and economic constraints, consideration of environmental and safety concerns along with the legal framework including the Intellectual Property (IP) Laws. These constraints are also depicted in Table 5 below and are labeled as specifications. Often, the author's capstone projects may have a dominant software component. Thus, Software Requirements Specifications (SRS) development is also included in the project design and documentation. More information on this is given in the discussion section of this paper.

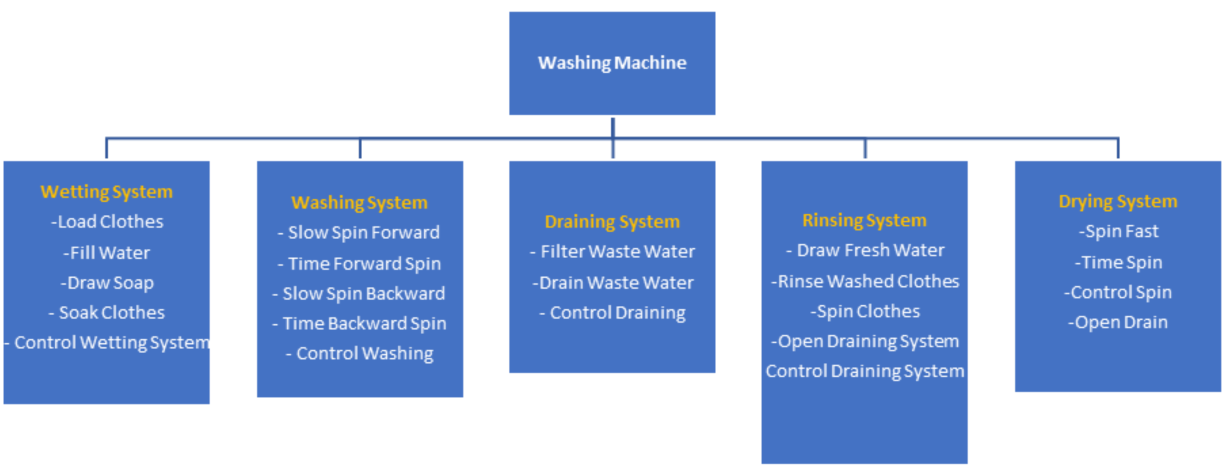

Figure 3. Function tree of a washing machine [16]

Table 5. Specifications table for a can crusher for recycling

Metric	Value
Dimensions	20 x 20 x 10 cm
Cans crushed	1/5 original volume
Weight	<8 kg
Sales price	<$60
Number of parts	<50
People able to use	> 5 yrs

Probability of injury	<0.1%
Manufacturing cost	<$150
Steps to operate	1
Maintenance cost	<$10 annually
Efficiency rating	>95 percentile
Internal parts enclosed	100%

Use of engineering standards and codes is promoted with the introduction of the syllabi of the courses and enforced throughout the projects, as student teams work on their design projects. These may have a major impact on the specifications of the intended design.

Following section covers an activity that the author conducts during class time in both of his classes after exposing the students to the content given above, in this section of this paper.

A Solar Distiller Case

Students are asked to participate in the activity of designing a solar distiller. This area was selected since ABET sees sustainability as an important part of engineering design and problem-solving practice today. Creating a solar water distiller from reclaimed materials is a classic engineering challenge that balances thermodynamics with sustainable design.

Every time the activity is carried out, slightly different results are achieved since the author only guides the students but does not direct them to the same outcome. Below is a structured problem statement, including an introductory statement for justification:
Recent data indicates that slightly more than a quarter of the world’s population [18] including many remote and water-stressed communities lack access to “safely managed drinking water”, yet often have plenty of solar radiation and discarded materials like wood, plastics, glass, and metal. Current commercial water purification methods are often too expensive or rely on non-renewable energy sources. Thus, there is a critical need for a low-cost, sustainable water purification solution” that “can be constructed from reclaimed materials to provide potable water through solar distillation.”

If we rephrase the argument above, we arrive at a problem statement that is reasonably acceptable to the author: “"Communities with limited resources need a way to convert stagnant or contaminated water into safe, drinkable water using only locally available materials and solar energy, in a design that is easily transportable for mobile or temporary use." This need statement will produce the following goals:

- Obtaining water that meets the potability requirements (water safety)
- Maximizing the volume of clean water obtained by the distiller using a reasonably small solar input (efficiency/efficacy)
- Mostly using reclaimed or recycled materials (sustainability)
- Ensuring that this distiller can be carried by a single individual (portability/durability)

The water safety goal relates to the environmental protection objective of the project – maintaining water purity, leading to the two functions given below:

- *Containment*: Creating a hermetic seal to prevent contaminants from entering and vapor from escaping (e.g., gaskets or silicone).

- *Collection*: Storing clean condensate into a safe and separate compartment.

The efficiency/efficacy goal relates to the thermodynamics related objective of the project – maximizing the distillation rate or volume with each cycle, associating with three different functions that are expected from this device:

- *Heat Absorption*: Maximizing solar gain using dark-colored reclaimed basin materials (e.g., tire rubber or black metal).
- *Vaporization* of Water: Minimizing depth of water (height of the corresponding device part) to reduce the time to reach evaporation temperature.
- *Condensation* of Vapor: Maintaining a high temperature gradient between the basin and the cooling surface (e.g., glass).

The portability/durability goal relates to the structural objective of the distiller, leading to the functions listed below:

- *Structural Integrity:* Withstanding wind and other minor disturbances, even with using a lightweight but a robust frame (e.g., PVC or wood).
- *Transportability:* Designing for "foldability" or including handles for easy transfer.

Table 6. Specifications table for the solar distiller

Metric	Value
Materials	Must be at least 80% reclaimed or recycled materials
Portability	Must weigh less than 11kg (24.2 lbs) and fit within a footprint of 0.5m x 0.5m (~1.64 ft x 1.64 ft) when packed.
Depth of Water	Must be less than 10 cm (~3.94 in) for minimizing evaporation times
Output	Must produce a minimum of 2 liters (~0.528 gal) of clean water per 6 hours of sunlight.
Cost	Out-of-pocket costs for new materials (e.g., adhesives, sealants) must not exceed $15 USD.
Water Safety	Final water output must have a Total Dissolved Solids (TDS) count less than 500 ppm.
Airtightness	Vapor loss must be minimal to the distiller to maintain a hermetic-like operation.

Discussion

Alternative to the approach employed in this effort is “Design Thinking”, which has been gaining momentum in many engineering disciplines. It is a methodology used in the problem definition stage of engineering design and problem solving [19]. While this paper is based on traditional engineering design and problem-solving practice, with the business and technical details at the core of its focus, Design Thinking is centered to human-experience, or simply human centric [20]. The most common way to write a problem statement in Design Thinking is the “Point of View” (POV) statement [19][21]. It uses a style format to ensure the designer stays focused on the user: [User/Persona] needs [Need/Goal] because [Surprising Insight/Motivation]. If we employ the solar distiller problem from the previous section of this paper, we can make modifications to impose the humanistic touch:

- User: "Migrant families living in temporary coastal camps in Aegean..."
- Need: "...needs a way to purify seawater using only the debris they find around them..."
- Insight: "...because they see permanent equipment as a liability when they have to move suddenly, and they prioritize gear that can be 'built and abandoned' with no additional cost."

Once the POV is in place, the designer turns it into a How Might We" (HMW) question. This is the part of the problem statement that kicks off brainstorming [22]. A good HMW is broad enough for creative freedom but narrow enough to be manageable [23].

- Too Broad: "How might we solve the world's water crisis?"
- Too Narrow: "How might we make a solar distiller out of a 2-liter soda bottle?"
- Just Right: "How might we help displaced families create lightweight, high-yield water filters from common campsite waste?"

In terms of approaching the problem statement, the following sequence guides the designer towards it:

1. *Synthesizing the Understanding:* Look at your "Empathy Map." What did you hear, see, and feel? [21]
2. *Identify the "Pain Point*": What is the biggest emotional or physical hurdle for the user? [19][20]
3. *Finding the "Why":* Why is this a problem? (Use the "5 Whys" technique to get deeper than the surface level). [24]
4. *Drafting the POV:* Plug your findings into the format above.
5. *Checking for "Solution Bias":* Ensure your statement doesn't accidentally suggest the answer. (e.g., Don't say "The user needs a website"; say "The user needs access to information"). [19]

In Design Thinking, the problem statement isn't handled only once. The designer usually iterates by following a loop with the steps of: Empathize, Define, and Ideate.

1. *Empathize*: Talk to people or simulate their environment. (e.g., Try to build a distiller using only what's in your recycling bin today).
2. *Define*: Realize that the hardest part isn't the heat; it's the *seal*.
3. *Ideate:* Your new problem statement becomes: *"How might we create an airtight seal using only common household waste?"*

This iterative approach is employed in readjusting the POV.

Additional approaches like, Software Requirements Specifications (SRS) development are also included in the authors' course projects, sometimes by itself, or along with the problem statement development if the project is in cross-disciplinary nature with a major software component. SRS serves as a formal agreement between clients and the development team on what the software will do and how it will perform. An SRS document is structured to provide a comprehensive description of the software's purpose and environment before going into specific technical needs [25].

The SRS documents begin with defining the Purpose, Product Scope, and Definitions. This section ensures that all terminology is consistent across the project to avoid ambiguity [25]. This is followed by Functional Requirements such as user interaction, data handling, and error handling [26][27] and Non-functional Requirements such as performance (e.g., response time and resource use), reliability and availability (e.g., required uptime and failure recovery protocols), as well as security for data encryption and user authentication [25][28]. Every SRS must also account for Design Constraints, such as specific programming languages or hardware limitations (e.g., the software must run on a low-power Arduino microcontroller) [25]. Furthermore, requirements must be Verifiable; if a requirement cannot be tested, it is considered poorly written [29].

Conclusions and Future Work

In addition to approaches mentioned above, including their examples, the author occasionally employs Quality Function Deployment (QFD) tools as well as examples of Failure Modes and Effect Analysis (FMEA), where students can use these as references to judge amongst multiple alternative concepts. This effort highly depends on the complexity of the designs in concern.

The author strongly believes in importance of successful structured problem development, and its impact on student teams' performances. If we look at the two examples given below (produced by students), they have some parts of a complete problem statement, however they still require adjustments based on the points delivered earlier, including a "clear need statement" separated from "identified" goals and objectives, with the earlier example being better, but includes solutions. They both also lack constraints. The author will discuss these and other similar examples during the presentation showing the fixes they needed and how they were done:

- "Traditional farming methods require large amounts of water, soil, and labor. Urban and indoor environments face limited access to fertile land and space. The project's goal is to design a compact and automated hydroponic system that:
  ○ Minimizes water usage
  ○ Automated nutrient delivery
  ○ Supports efficient plant growth in small spaces
  Our system uses pumps, nutrient reservoirs, and tubing to circulate water and nutrients to plants."

- "Traditional card dealers and shufflers often perform with limited functions, handling either dealing or shuffling but rarely both. These devices are inefficient and lack adaptability for various card games and to perform both functions. Players still rely on manual actions, due to the lack of both features forcing users to either deal or shuffle manually, leading to uneven distribution and slower gameplay. The Optimus Dealer project defines the problem as the need for an automated, reliable, and modernized card handling system. A card handling system that integrates both shuffling and dealing functions with advanced features like camera recognition and remote operation to enhance speed, accuracy, and user experience."

Future work will involve use of the HBDI in selecting the team membership even though both the capstone and junior/senior elective teams are made up of multiple different engineering majors with different strengths. In addition, the author is planning to present two different examples of the solar distiller problem, a new being the use of "Zero-Tools" to challenge the students further during the course discussions.

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