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Figuring "It" Out: Informational Literacy for Problem Scoping in Engineering Design (Theory)

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Abstract

We live in a digital age, where we have access to a plethora of information at our literal fingertips. The relative speed of getting an answer has fundamentally changed the way that individuals locate and process this information. The intersection of engineering and library science delved into the field of informational literacy, which investigates the skills necessary to locate, evaluate and effectively use the needed information. This information gathering stage is important in the problem scoping stage for “wicked” open-ended engineering design problems.

Studies have shown that differences exist in how high schoolers, first-year students, senior students, experienced engineers and even preschoolers approach problem scoping and information gathering. This paper will outline the key research at each of the stages (preschool to engineering expert) to determine what key differences and/or similarities exist such as the role of context, information gathering, and the ability of the individual to discern the necessary information (application). Observations from multiple-units on informational literacy for problem scoping in a first-year engineering program will be presented.

There is a distinct connection between information gathering and problem scoping.

Instead of spending hours in a library index or heading to a trusty set of Encyclopedias, the advent and current reliance on the internet has fundamentally changed the way that individuals locate and process information. We are now part of the “Google” generation whom lives, learns and works in an increasingly complex world chocked full of informative, persuasive and sometimes untrue pieces of information. The relative ease of access to differing information sources impacts both the quality and quantity of information used.

Engineering design problems are considered to be “wicked” – meaning that they are complex and ill-defined with regards to constraints and criteria. Problems of this nature often have multiple levels of conflicting criteria or constraints. In many cases this information isn’t readily available and the lack of definition relies on the information gathering skillset of the individual investigating.

Information gathering behavior is expressed in various forms, but at its core is the process of collecting, receiving, and discriminating amongst information. Often this is considered under an umbrella term of informational literacy – which is an individual’s ability to locate, evaluate and effectively use needed information. Processes involved during information gathering may include published or unpublished print materials, communication with human “experts” (e.g with peers, family, or librarians), and tactile processes (e.g. trial and error, experiments, etc.) (Figure 1). In addition, these interactions can take place in person or in virtual spaces.

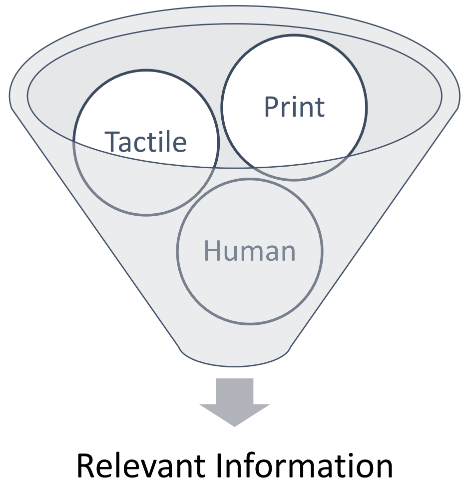

Figure 1. Different sources for information gathering.

High school students often rely upon the internet for the acquisition of information, with heavy reliance upon website that are more popular and persuasive in nature (as opposed to technical and informational) [1]. Even undergraduate students show a preference for quick, easy, and convenient alternatives to gather information that often preclude them from actually visiting an actual library [2-3]. However, even with library instruction, undergraduate students still rely on Google as a main source for their information gathering needs [4]. Reasons for this include a disconnect in the relevance of library instruction and low self-efficacy in their ability to use library resources for information searches [2].

While this probably doesn't come as a shock to many individuals, it still provides a nuanced understanding that students perceive the need for information without evaluation of the source material. In essence, it is an issue of quality (usually low) over quantity (sometimes too much). Previous research has suggested that the information gathering process was not correlated with the end-solution quality [5], though that was in direct contrast with previous research the suggested the opposite [6]. Therefore, it might not be the student's ability to gather a certain amount of information, but rather the breadth, relevance or quality of the information that is a determining factor influencing solution quality [1]. If the current trend of information gathering practices primarily rely upon a single source (aka the internet) there is the potential for the solution space to be impacted. This has implications for engineers as gathering information and application is a dominant aspect for problem scoping within the design process.

Schön (1983) was one of the first to define problem scoping as defining the problem, framing the context in which it sits, and delineating criteria by which design will be evaluated [7]. However, this definition has been expanded to include identification of constraints, goal-development, context, information gathering, problem framing and reflection [8-12]. This paper will focus on the elements of information gathering and application of context, along with ability to discern appropriate information.

Problem scoping is considered to be crucial at the outset of the engineering design process where information can not only be used to both develop solutions, but also to redefine the initial problem framing during the progression of the process. Problem scoping in this vein is the ability to determine the aspects of problem that need more consideration. For example, determining the role of stakeholders, such as utility companies and Native Americans on the management of a reservoir system, or understanding the limitations of nanomaterials used in the development of medical devices. It is surmised that if an individual does not fully understand the problem at hand, they will be unable to develop an appropriate solution.

Individuals at any stage have the capability to engage in problem scoping.

Problem scoping is a skill that engineers and designers need to continually develop in order to be effective. Most research into problem scoping focuses upon a single population but this paper posits that problem scoping occurs at any stage and is centered upon three different areas of commonality: role of context, information gathering, and the ability of the individual to discern the necessary information.

Preschoolers are natural engineers as they question the world around them, try to find solutions to problems (granted based on incomplete knowledge) and incorporate their experience to the matter at hand. While limited studies have investigated this natural ability, there is evidence that preschool children can engage in developmentally appropriate engineering experiences that are comparable to those of experienced engineers [8, 10-11] This engagement includes problem-scoping behaviors such as identification of the problem, goal seeking, identification of constraints and interaction through contextual factors. [8]

During a study investigating how very young children and their parents engage in meaningful engineering activities within a museum context, findings highlighted problem scoping and idea generation as both possible and frequent interaction during the process of the engineering activity [8-11]. Preschoolers (aged 4-6) were able to identify constraints, look at the feasibility of a problem and even add in additional context to further the design agenda [10]. In addition, preschoolers were observed to add extra contextual layers to the problem if it was originally ill-defined [10]. These behaviors were observed to occur more frequently when parents took on a less directing role. [11] Additional problem scoping competencies found in research include asking questions and explaining cause–effect phenomena [12]. Preschoolers in these studies often rely on human capital, aka “experts” to discern information through questions and feedback mechanisms for their information gathering needs.

Very few studies have investigated the potential for elementary students to engage in problem scoping behaviors. Studies have shown that young student engage in specific problem scoping behaviors such as problem naming (evaluation of user needs, considering criteria/constraints), determining the context, and reflection as early as Kindergarten up to sixth grade [13-16]. However, these behaviors have been observed to be inconsistent, and are dependent on the problem and the context given. Oftentimes students lack the language to clearly define their systematic method they follow. As they progress through the design process they often lose sight of the problem and become fixed on the solution space [16]. At this stage, student still rely on human "expert" interaction and some print for their informational needs.

During high school years, students have some exposure to traditional informational gathering techniques (e.g. book and digital sources), but even exposed to curricular units on informational literacy, many students still struggle to evidence strong information searching and critical evaluation skills [17]. High school students engage in design thinking with little understanding of the problem from the client's perspective. Students tend to become fixated on a single solution rather than spend time helping to further define the problem [1].

A majority of the research on problem scoping has been conducted with undergraduate engineering students, with comparison to practicing engineers [18-23]. More experienced engineers are observed to spend more time gathering information for understanding a problem than those with less experience [20].). Experts are expected to scope a problem in such a way that they adequately account for context. These "experts" often spend considerable time gathering information to clarify problem criteria/constraints, determine if solutions are untenable, serve as information for ideation and address any deficiencies in knowledge. Although undergraduate students and experts spend a substantial amount of time modeling a problem, students spend little time gathering information than experts. Additionally, it was found that undergraduate women's responses were more likely to be context-oriented than men's [21] (Kilgore et al 2013).

Observations from a first-year engineering program on problem scoping

One of the learning objectives of a first-year engineering program at a private, mid-sized institution (n = 154) is to develop foundational analytical and written communication skills appropriate for the field of engineering. Over the course of the fall semester, three different activities were implemented regarding problem scoping and informational literacy.

The first task was a hands-on activity in which the students had to design a tower out of a deck of playing cards, tape, and scissors. The objectives of this activity were to introduce stakeholder perspectives and demonstrate the importance of problem scoping. Each team was provided with a list of criteria and constraints, with the instructors and T.A. acting as the client and the manager. In the timed activity the student teams had to design an elevated viewing platform to meet the criteria/constraints, build and eventually test. Many of the criteria and constraints were left to be intentionally vague and a clarification script was provided for the instruction team if questions were posed. Without this additional information it would be very difficult to have a successful design. During testing the students began to realize the importance of asking questions as the outset, and reflected on their interactions regarding their problem scoping.

> *"Although we had a general idea and knew we wanted to incorporate triangles into out structure, we did not think through our plan, criteria, or constraints enough before we started. One take away from this project is to take time to get information before you start."*

> *"We began building way too quickly, which ultimately created a design that was both messy and unsafe. We should have asked questions, played with the materials, drawn out a simple base design, divided the tasks, then began building. This process would have resulted in a design that actually met the criteria and worked."*

> *"As ambitious and excited one might be to simply jump into finding solutions, there is a lot of information that needs to be sought out beforehand. This is the most important step that can be applied to future designs by asking as many questions as possible so the ideas for the design are as clear as possible. "*

Out of the 40 teams, only three teams were successful in meeting all the requirements.

University librarians also presented a traditional lecture on informational literacy, demonstrating the "CRAAP model" which evaluates **c**urrency, **r**elevance, **a**uthority, **a**ccuracy, and the **p**urpose of source material (originally developed by Meriam Library at the University of California, Chico). Students were expected to use the University library stacks to find book source material, use online engineering databases to find a digital journal article, and properly source their information using a citation management software. In a subsequent assignment, students were expected to use that knowledge to develop an annotated bibliography. A majority of the students were able to locate reputable sources but not one used a physical resource (aka book).

Lastly, in a culminating project, the students were tasked with gathering information regarding a reservoir system in the Pacific Northwest. This assignment was part of a larger engineering modeling project that would explore mathematical relationships through iterative steps using Excel. To engage more deeply with the subject matter, students had to gather information regarding the local waterway system located close to campus. The assignment had a two-part assessment strategy – the first was to determine the ability to use the resources gained through a one-time informational literacy program designated through the University Library and the second was to asses the types of source materials the students used.

All three of the activities centered around problem scoping and informational literacy were closely related to previously mentioned research findings in that internet sources were the predominant source of information gathering and novices tended not to engage with an "expert other". Reliance on the source of information for finding "it" out relied predominately on preassigned information and brief internet searches.

In today's digital landscape, individuals of all ages have a responsibility to use information in an informed way. This is especially relevant for first-year engineering students that are transitioning into the professional space in which "wicked" problems will be present. Instruction on the availability of higher quality information, especially information found in places other than the open web, needs to take place. In addition, instruction and curriculum materials should promote student ability to search resources more efficiently.

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