StartSOLE Center at
Cleveland State University

StartSOLE
Let Learning Happen

Using Self-Organized Learning Environments to Increase Awareness and Interest of the Engineering Profession among Novice Educators and Young Learners

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There are many successful programs across K-12 in and out of school that introduce students to engineering. These show results in building engineering mindsets. The challenge is that these programs require specific structuring, resources, and time to implement. Further, they require trained individuals to lead the process. This fundamentally limits the exposure to engineering to those environments where these affordances are present, which is only a small subset of all environments where learning takes place.

STARTSOLE uses a fundamentally different approach to introduce engineering mindsets into K-12 students by educators who have no initiation or training in this area. This investigation examines the deliberate repurposing of a companion mobile application that facilitates self-organized learning using engineering as a context and implemented seamlessly in the natural K-12 classroom environment with no change in a teacher's exigent scheduling. This is a fundamental shift intended to overcome teacher's fear of science and technology, build confidence in delivering engineering content in an authentic way, placing the student at the center of the learning and discovery.

STARTSOLE is a mobile platform application that was designed and launched as a pilot in 2014. The design objective for the STARTSOLE application was to provide educators with a tool to help seamlessly incorporate inquiry learning into the natural classroom environment without any special preparation or extensive training of the educator. There are currently effective approaches to use inquiry methods—most notably problem-based learning—but these approaches require extensive training and preparation on the part of the educator. They also often require special teaching modules that must be inserted into the educator's already busy class schedule. The logistical complexity of delivering inquiry-based learning in this fashion makes it feasible for only a small fraction of educators.

Rationale and Background

> ***"Engineering work is focused on resolving an undesirable condition through the application of technologies. The technologies involved may be well-established, nascent, or as-yet unimagined. There, a central (if not the central) activity of engineering work is solving problems" (Sheppard, Colby, Macatanga, and Sullivan, 2005, p. 430)."***

What are self-organized environments and why might they matter to understanding engineering as a profession? Providing engineering related experiences to elementary school-age students allows these students to examine meaningful real-world problem as the basis for developing their own proposed solution. Equipping educators with facilitation skills to guide this experience using a systematic design process (e.g., the engineering design process – EDP), and to associating this work with the engineering profession, situates learning in a way that stdents and educators can understand what engineers "do."

Fostering interest among young minds in engineering careers is challenging for teachers who have not been trained in the methods of engineering education. These educators rarely have the knowledge base to adequately address all of the future possibilities within the engineering field for their students. Educators, such as counselors, play a significant role in student career choices yet they also feel very unprepared about rudimentary knowledge of engineering careers (Gibbons, Hirsch, Kimmel, Rockland, and Bloom, 2014). This is further exacerbated when students in their formative middle school years are turned off by a misguided prospect that engineering is not interesting because it is not discussed at the level of other highly visible career choices (Gibbons, Hirsch, Kimmel, Rockland, and Bloom, 2004).

Inspiring interest and accurate awareness of the engineering profession at a broad scale will depend on educators in- and out-of-school having access to easy-to-implement teaching practices that allow then to create an inquiry-based learning environment structured to simulate what then engineer does in their professional practice. Results of early in a facilitated process application called STARTSOLE shows potential to accomplish this.

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The STARTSOLE Process. In its present configuration, the STARTSOLE process begins by having students in small groups consider a research question provided by the teacher or educator or by the students themselves. The educator has been provided a STARTSOLE mobile application that provides interactive, guided facilitation for a short, high-impact inquiry learning session. The interactive, web-based application connects the educator to a community of other STARTSOLE users (as of mid-2018, this community included more than 7,500 educators living in 85 countries). Each student group typically has two devices with access to the internet. Students spend approximately thirty minutes researching the question and preparing a presentation in a group (between 3-5 students). After the research period, each group then presents to the class and discussion follows.

This process is iterated weekly or biweekly by the teacher with a different question each week. Figure 1 illustrates the STARTSOLE process:

FIGURE 1 - THE STARTSOLE PROCESS

SOLE pedagogy is modeled as a catalytic innovation that sanctions the student to explore multiple new dimensions of autonomy while quickly sharing connectivity with a group of peers. It strengthens collaborative competency by the nature of the task. Though it draws on the need for interaction, it is a communication shaped by conversation and negotiation, which emerges through inquiry, data collection, shared experience and reflection. The rapid collaboration required to accomplish these goals allows students to develop clarity, accuracy and precision, as well as the ability to integrate sound evidence, with an appreciation for equity in the process. Critical thinking is mandatory for reaching mastery in the methodology. STARTSOLE addresses a problem voiced by motivated students who indicate that while inquiry learning methodologies can be invigorating, when the classroom environment where it is practiced is overly structured by an educator, their allowable range of inquiry is stifled, and they become more frustrated rather than inspired (Rop, 2003). In one deep investigation of the motivated learner, “students suggest that the social atmosphere… is stacked against scientific inquiry. They feel their questions are not always valued, encouraged or given time to flourish,” (p. 13). For the present research study, STARTSOLE questions will be developed by an engineering advisory board comprised of practicing engineers, post-secondary engineering program educators, and learning theory experts. Technology has opened the door with access to the knowledge economy, and it must be integrated into learning today, as it provides the gateway to exploration outside the traditional academic sequence.

In the self-organized learning environment created through STARTSOLE, students must participate in information collection, apply newly learned skills, analyze their progression within the group, blend it with existing knowledge, synthesize relevant information, and finally prioritize that information in order to present it to others. An important element of STARTSOLE is the scaffolding it provides for the educator to effectively facilitate the creation of this learning environment. The effectiveness of process-related collaboration tools is based on the skill of the facilitator. This dependency is often why processes (like EDP) fail to meet their potential when scaled to broader groups because “skilled facilitators are scarce,” (Wong and Aiken, 2003, p. 125). Wong and Aiken (2003) conducted research on the use of automated facilitation tools and their results showed that these tools can increase the performance of novice facilitators. The extent to which this promising empirical evidence extends to STARTSOLE will be part of this investigation. An example of STARTSOLE can be experienced at www.startstole.org.

STARTSOLE incorporates data and artifact collection as an integral part of the application design. Educators can capture photo and video to document the work in groups, as well as upload student final work and presentations for archival purposes. These data will be included in the set of information used for the evaluation phase of the present study.

THEORETICAL FRAMEWORK

Cognitive apprenticeship theory is the lens through which STARTSOLE is being explored for raising awareness about engineering.

The social context is a critical factor in apprenticeship. The traditional apprentice learns many important cognitive tasks simply by being embedded in the environment with others and observing the work to be done in context. The environment itself is diverse. A learner experiences that there are numerous approaches to solving problems and there are also a range of skills among the learners and masters. Not everyone possesses all the skills to accomplish a task. But together, with methods to understand progress through design, trial and error, and iteration, complex tasks are successfully accomplished.

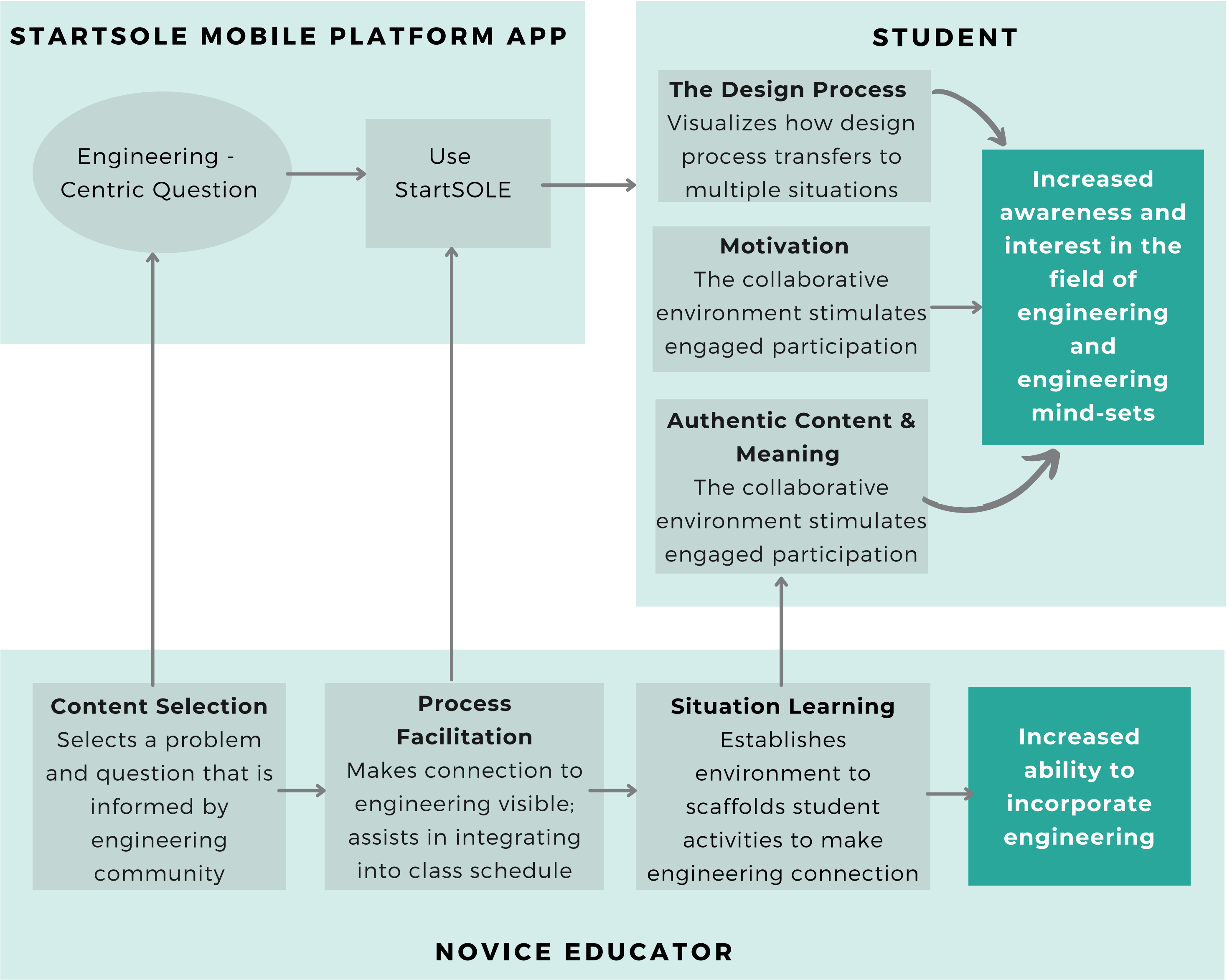
The theory of cognitive apprenticeship translates the situated learning outcomes from the traditional place-based apprenticeships into a classroom environment (Collins, Brown, and Holum, 1991). The learning theory incorporates three features:
“In order to translate the model of traditional apprenticeship to cognitive apprenticeship, [educators] need to: (1) Identify the processes of the task and make them visible to students; (2) Situate abstract tasks in authentic contexts come so that students understand the relevance of the work; and (3) Vary the diversity of situations and articulate the common aspects so that students can transfer what they learned.” (Collins et. al, 1991, p. 3)

CONCEPTUAL FRAMEWORK

The conceptual framework our work is cognitive apprenticeship theory directly in the context of engineering as both a profession and a mindset. The framework applies to both educators and to students. For the purposes of the present paper, the term “novice educator” is used to designate educators who are: (1) unfamiliar with the profession of engineering, and (2) unfamiliar with creating and facilitating self-organized learning environments. The conceptual framework includes two distinct aims for the novice educator and student.

As shown in Figure 2, engaging in a STARTSOLE experience aids both the educator and student in component areas aligned to NSF’s Broadening Participation in Engineering (BPE) Program. The selection of an engineering-centric question initiates this process. A central hypothesis of the proposed research is that a well-crafted question can activate inquiry that leads the participating students in a direction that naturally invites engineering behaviors. A companion hypothesis is that knowledge of science and engineering, per se, is not a requirement of the novice educator to effectively facilitate a meaningful engineering experience that is scaffolded by STARTSOLE. Cognitive apprenticeship theory posits that the educator – aided by the STARTSOLE application – will support the student’s use of design processes in content areas that are meaningful and memorable to the student. Interactive coaching from the STARTSOLE application reinforces the student’s mimicry of the engineering mindset by highlighting the parallels between specific engineering professions and the problem/solution journey of the participating student. The set of questions developed by an engineering advisory group span a wide range of topics that are applicable across STEM and social sciences so that educators across these topics can all participate.

FIGURE 2 – CONCEPTUAL FRAMEWORK



At minimum, it can be argued that experiencing activities that require engineering mindsets is a beneficial skill regardless whether a student intends to pursue engineering as a profession or not. This aim is inherent in the present proposal as being necessary, but not sufficient. As noted earlier, teachers are generally not familiar with the roles and required preparation necessary to become an engineer. The fruits of the laborers of engineers are manifold in current society and throughout important milestones in our history.

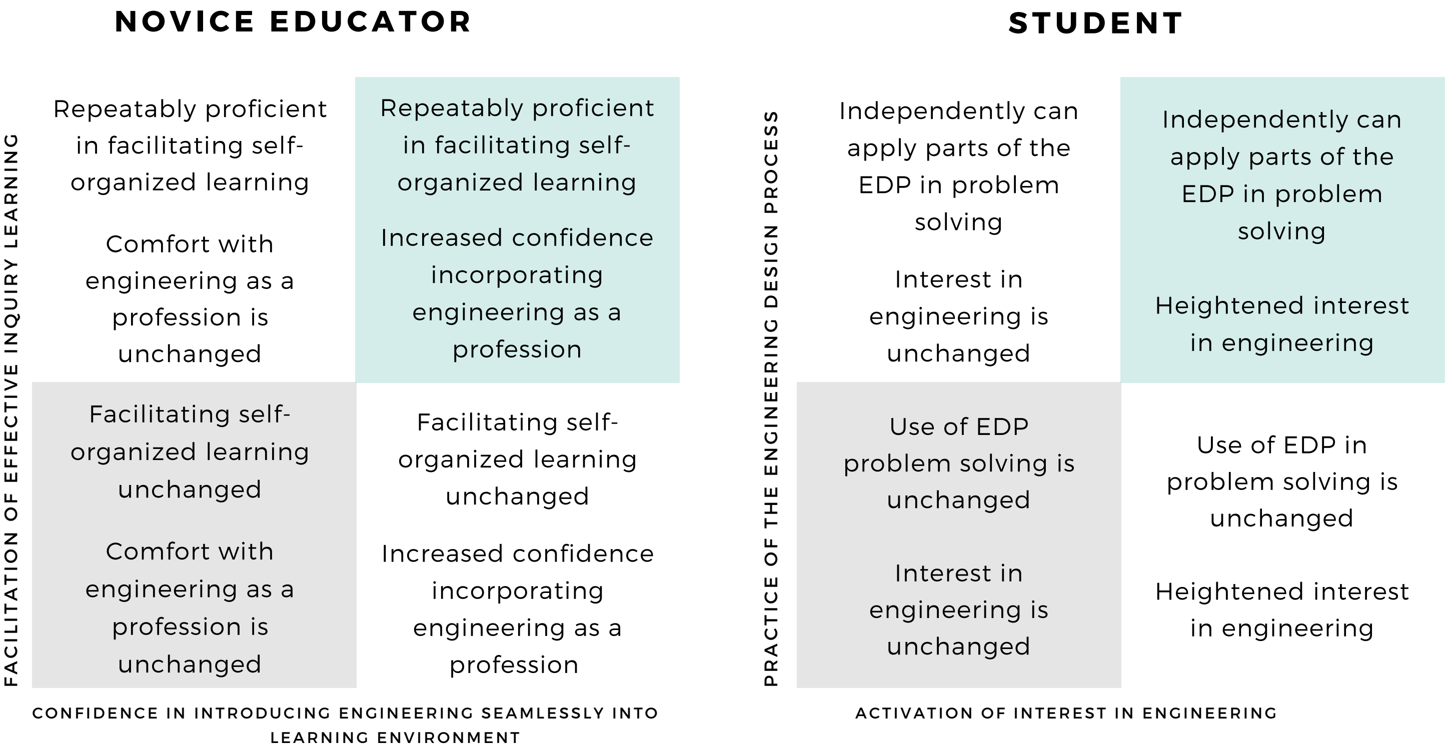
While it is generally known that engineers participated in these events, the specific daily life and activity of what engineers do is not widely known among primary/secondary educators and counselors. Therefore, the ability to confidently represent these fields especially to young learners is a missed opportunity. Enabling educators with the requisite knowledge of what engineers do, what they look like, and how they contribute to the world at large is anticipated to be inspiring content that educators would be excited to use if the approach fit within their educational day and aligned with objectives they already have for their course outcomes.

The STARTSOLE application is designed to identify and align with Common Core Standards enabling it to be complementary to an educator's teaching activities. Pilot studies informing the present proposal show that educators use STARTSOLE because it does not require making room in a schedule as "extra work."

EVALUATOR DISCLOSURE STATEMENT

In our continuing research regarding STARTSOLE's benefit to this area, of specific interest an examination of how attitudes and awareness of the engineering profession change as a result of exposure to the STARTSOLE facilitation experience. Figure 3 is a graphical illustration of the possible set of outcomes we are exploring.

FIGURE 3 – MAP OF POTENTIAL OUTCOMES FOR NOVICE EDUCATORS AND STUDENTS



NOVICE EDUCATOR

Repeatably proficient in facilitating self-organized learning Comfort with engineering as a profession is unchanged	Repeatably proficient in facilitating self-organized learning Increased confidence incorporating engineering as a profession
Facilitating self-organized learning unchanged Comfort with engineering as a profession is unchanged	Facilitating self-organized learning unchanged Increased confidence incorporating engineering as a profession

FACILITATION OF EFFECTIVE INQUIRY LEARNING

CONFIDENCE IN INTRODUCING ENGINEERING SEAMLESSLY INTO LEARNING ENVIRONMENT

STUDENT

Independently can apply parts of the EDP in problem solving Interest in engineering is unchanged	Independently can apply parts of the EDP in problem solving Heightened interest in engineering
Use of EDP problem solving is unchanged Interest in engineering is unchanged	Use of EDP in problem solving is unchanged Heightened interest in engineering

PRACTICE OF THE ENGINEERING DESIGN PROCESS

ACTIVATION OF INTEREST IN ENGINEERING

This map informs three research questions that guide the direction of the investigation:

- RQ1 – What is the influence of engineering-centric questions on the novice teacher's confidence in making engineering content available as part of their learning environment?
- RQ2 – How does a student's interest in engineering as a profession change as a result of participating in a STARTSOLE experience using engineering-centric questions?
- RQ3 – What challenges and barriers are cited by educators about engineering, and how do these change as a result of exposure to STARTSOLE?

Broader Impacts

The STARTSOLE application was designed to facilitate an educator's ability to seamlessly apply inquiry learning without prior training. Our pilot work shows that it can be used directly by educators, in their natural environment, and no special affordances are required. Over the period 2014-2018, STARTSOLE has established an installed base of over 13,000 educators (predominantly K-12) living in 90 countries. These educators work in 2,426 schools, and the STARTSOLE experience has conservatively reached over 500,000 K-12 students. As part of the pilot launch of STARTSOLE, a data collection system was integrated into the delivery and use of the mobile application that allows researchers to understand how STARTSOLE is used in classroom settings.

STARTSOLE has the potential to bring student-centered inquiry learning into every classroom and into the hands of every educator. Most K-12 educators have little experience in the engineering design process. STARTSOLE has the potential to facilitate a teacher's ability to introduce the key elements of engineering without any prior preparation or training in the engineering design process. As a result, STARTSOLE is at the stage where, with the aid of concerned foundations and organizations, continued exploration can determine if STARTSOLE can significantly accelerate the penetration of principles of engineering and excitement about the engineering profession into everyday classroom environments.

FOR FURTHER INFORMATION, PLEASE CONTACT THE LEAD AUTHOR AT JEFF.MCCLELLAN.9@GMAIL.COM