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Translating Evidence on Asset-based Pedagogies into Engineering Education Practice

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Gimantha Perera is a Sri Lankan born researcher and educator from NC State University. He was inspired to be an engineer by his maternal grandfather Anil, who would consistently come home from work covered in grease and grime after climbing bodily into machines to fix them. He shares a promise with his grandfather, now departed, that he will continue to innovate, contribute, and revolutionize industry through engineering and teaching. His world view that can be summed up in two statements: ”Just because it works, doesn't mean in can't be better.” – Shuri, Black Panther and ”First, think. Second, believe. Third, dream. And finally, dare.” – Walt Disney. He obtained a Bachelor of Science in Industrial and Systems Engineering from North Carolina State University while a part of the Accelerated Bachelors-Master's program. He proceeded to finish his master's at North Carolina State University under the guidance of Dr. Julie Ivy and Dr. Karen Chen. ”I want my life to have mattered, I want to look back and feel like I made a difference in my brief time here. I know I won't always be able to do this but I want to look back at the people in my life and not regret the ways in which I interacted with them; I want them to remember me and remember me fondly”. Emmerson said ”The purpose of life is not [merely] to be happy. It is to be useful, to be honorable, to be compassionate, to have it make some difference that you have lived and lived well.”, I hope to live up to that ideal in the service of science and my community.

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Introduction

In this evidence-based practice full paper, we describe an inventory of asset-based strategies co-produced by study participants and researchers in an ongoing, multi-year research project at a large, public, land-grant, Hispanic-Serving Institution. Asset-based approaches emphasize students' inherent strengths, lived experiences, and cultural identities as foundations for cultivating inclusive learning environments as well as promoting skill development among students [1], [2]. Despite promising evidence supporting the role of asset-based strategies in fostering student engagement and success [1], the uptake and adoption of such equity-centered practices are often limited in engineering education. The challenges associated with this research-to-practice gap can be attributed to a multitude of factors including curricular constraints, insufficient professional development opportunities for faculty, and a lack of practical, readily available guidelines for implementation [3]. While some training programs and institutional support do exist, they primarily focus on general active learning strategies and often fail to reach all engineering faculty, particularly those who may be less engaged in equity-related initiatives. Consequently, these programs fall short of making meaningful connections to relevant evidence and equipping faculty with the necessary tools and frameworks to implement asset-based practices effectively. To address these shortcomings, the overall project involves (a) organizing faculty professional development retreats aimed at promoting critical awareness of the evidence and potential of asset-based practices, (b) co-designing and implementing asset-based pedagogical innovations in courses with an emphasis on engineering design, and (c) engaging both student and faculty participants from those courses in appreciative interviews to assess the alignment between educational innovations and student experiences. In this paper, we present an inventory of strategies derived from our work to support the uptake and adoption of asset-based practices, with a focus on engineering design education.

Methods

As a part of the larger project, we invited engineering educators involved in undergraduate teaching courses with design or open-ended project components in a professional development retreat on asset-based practices, followed by a semester-long commitment to co-develop and implement asset-based innovations in their courses. We engaged nearly 30 faculty participants and 10 graduate teaching assistants. The faculty participants taught courses in a variety of engineering departments, including aerospace and mechanical engineering, biomedical engineering, civil Engineering, materials science and engineering, mining engineering, optical sciences and engineering, software engineering, systems and industrial engineering, and our interdisciplinary first-year and capstone design courses. The teaching assistants were from engineering and mathematics departments. The courses where innovations were implemented spanned from first-year undergraduate courses to fourth-year and master's level courses. Many, but not all, of these courses, included a focus on engineering design and team-based projects.

After the initial professional development retreat, we analyzed the resulting innovation plans and notes from debriefing and/or check-in sessions with participants and compiled an inventory of practical asset-based strategies that were designed or adapted by instructors, which is the focus of this paper. In addition to faculty participants, we interviewed a total of 21 students from courses where the instructors had participated in our professional development retreat. These semi-structured interviews proceeded from an appreciative stance (e.g., [4], [5]), with the goal of identifying successful teaching and learning strategies, from both student and faculty perspectives, and amplifying those strategies in a community of practice. More details and findings from the larger project are described elsewhere [3], [6]. Here, we present the rationale and consolidated implementation guides for exemplar asset-based practices from the inventory.

Informed by principles from participatory action research (e.g., application of immersion-crystallization analysis [7]) and Freirean pedagogy, the process of developing and disseminating the inventory of asset-based strategies emphasized critical dialogue and co-learning, where participants and researchers engaged in meaningful conversations to identify equity-oriented characteristics and promote critical consciousness for all. Specifically, during debriefing sessions with faculty participants, lack of structure and time emerged as the most frequently cited barriers to implementing asset-based practices in engineering courses. In addition, most participants expressed the need for readily available resources (e.g., implementation guides) for evidence-based practices and suggested that access to such resources would significantly increase their likelihood of adopting asset-based strategies, either by using them directly or drawing on them as inspiration to develop their own strategies and adaptations to their courses. We combined faculty feedback and innovation plans with students' suggestions on teaching approaches to identify generalizable, broadly applicable asset-based strategies. Thus, each strategy in the inventory is presented with attention to several attributes: applicability to individual students versus teams; extent of student involvement; timing such as stage in the design process; types of reflection involved; facilitation suggestions for educators.

Results

We identified four exemplar strategies from the inventory, including: (1) critical priming, a multi-phased strategy for fostering critical consciousness through reflective and interactive learning activities, (2) strength/asset mapping to identify and leverage individual as well as collective assets to promote team dynamics in design projects, (3) professional dialogues, an asset-based interviewing strategy, and (4) appreciative interactions, which employs language, including questions, rooted in appreciative inquiry during one-on-one interactions with students and when providing evaluative feedback.

Figure 1. Inventory of Asset-based Practices

Critical Priming

Priming is a cognitive scaffolding tool that involves pre-exposing learners to upcoming content through some form of structured interventions. Priming operates through the cognitive psychology principle of activating schemata i.e., mental frameworks that can organize and interpret information [8]. When students encounter pre-exposure materials (e.g., concept maps, selected reading assignments), related neural pathways become temporarily more accessible, which can facilitate faster and more effective learning. For example, biomedical engineering students primed with a simulation of the cardiovascular system before a fluid dynamics module are more likely to better integrate Bernoulli's principles due to pre-activated circulatory schemata. We define ***critical priming*** as an asset-based strategy designed to promote awareness of social, political, and ethical issues in a discipline of interest. For example, to help students understand potential bias that may impact their teaming and interactions with peers in an engineering design setting, educators can share evidence from psychological sciences about what stereotype threat is, how stereotype threat may affect students in science and engineering contexts, and how to lessen the impact of stereotype threat on students' performance. Evidence suggests that discussions of stereotype threat before a key assessment (e.g., exam or design review) can improve student performance on that assessment [9], [10]. Such critical priming prior to or during team-based design projects allows students to raise their awareness and potentially implement some behavioral changes towards others (e.g., not defining others by their gender or race or associated stereotypes) or themselves (e.g., using self-affirmation and questioning stereotypes that are applied to oneself).

Table 1. Consolidated Implementation Guide for Critical Priming

How to implement critical priming?
To facilitate critical priming, educators can consider the following suggestions: • Identify and utilize existing resources on relevant social/sociotechnical issues to help communicate using appropriate language and references (e.g., [11], [12] for stereotype threat). • Incorporate discussions of social concepts that might impact teamwork into a broader discussion of expectations of best practices for teamwork • Discuss with students how personal experiences (e.g., navigating bias and stereotyping; advocating for equity in professional spaces) have shaped the educator's academic journey and how they navigated these challenges. • Provide opportunities for students to reflect on their desired and actual growth in any technical, teamwork, or interpersonal skills throughout the semester.
Where is critical priming applicable?
Critical priming may be especially helpful in team-based design courses or multidisciplinary projects where understanding the impact of social factors is critical. It may be best introduced early in the team-based project when a project topic is introduced to support problem framing and requirements elicitation. For stereotype threat specifically, critical priming may also be useful before exams or project teaming where stereotype threat may be present for certain groups of students.
What are some potential outcomes of critical priming for engineering students?
Potential outcomes of critical priming include increased awareness of historical and sociotechnical issues, leading to better incorporation of contextual factors in design decision making. For stereotype threat specifically, critical priming could potentially lead to increased performance of individual students as they develop better coping mechanisms to combat stereotype threat. In team environments, as students raise their awareness, they may rely less on stereotypes to judge the behavior of team members and rely more on their complementary strengths.

Specific examples and adaptations of critical priming
• For stereotype threat, a multicomponent intervention can be offered including (a) a pre-exposure reading or visual activity related to stereotype threats and (b) a metacognitive writing task linking stereotype threats to students' existing perceptions and experiences, at two time points – before and after a team-based design project – which can allow students to reflect on their own performance, any struggles with stereotype threat they faced during the project, and their personal growth throughout the semester in short reflection assignments. • The priming prior to the design experience can be related to any historical and sociotechnical context of the problem rather than focusing solely on stereotype threats. For instance, before engaging in a water filtration system design challenge, students might explore case studies on water accessibility and environmental justice, such as the Flint Water Crisis [13] or inequities in clean water access in rural communities. This primes students to consider ethical, social, and equity-based factors in their solutions.

Strength/Asset Mapping

Strength/asset mapping is one of the more widely adopted strategies to identify and leverage the individual and collective strengths within a team to enhance dynamics and collaboration, particularly in the context of engineering design projects [17], [18]. This approach recognizes that each team member brings unique skills, experiences, and perspectives that can significantly contribute to the success of a project. Engineering teams can foster a deeper understanding of their collective capacity, align roles with strengths, and develop a shared vision for their work. In design projects, where innovation and collaboration are key, strength/asset mapping provides a structured framework to promote inclusion, mutual respect, and efficiency. The process also builds a culture of appreciation and collaboration, encouraging team members to recognize and celebrate their contributions to the shared goal.

Table 2. Consolidated Implementation Guide for Strength/Asset Mapping

How to implement strength mapping?
To facilitate strength mapping within teams, educators can consider the following suggestions: • Encourage team members to reflect on their personal strengths, skills, and lived experiences, focusing on how these relate to the project goals. • Facilitate a team workshop where members share their reflections and collaboratively identify collective assets, which can include technical skills, creative abilities, leadership qualities, and other relevant attributes. • Have students create a visual map that captures individual and team strengths, with emphasis and synergies (consider free or open-source versions of mind mapping tools such as Google slides, bubbl.us). Sample Prompt: *Create a visual map of your strengths, including your skills, experiences, and interests, that you bring to this course and/or project.* • Encourage teams to use/re-use the map to assign roles and responsibilities based on team members' strengths, while ensuring alignment with project needs.

• Encourage teams to revisit and update the map at key project milestones to reflect growth and evolving dynamics.
Where is strength mapping applicable?
Strength/asset mapping is particularly useful in team-based design courses or multidisciplinary projects where collaboration is critical. It is applicable at various stages, such as team formation, project planning, and major decision-making junctures. This strategy can also be adapted for use in research collaborations or community-engaged projects. It can also be applied at the individual level to help students identify and leverage their unique assets for personal growth and project contributions.
What are some potential outcomes of strength mapping for engineering students?
Strength/asset mapping fosters improved team cohesion and collaboration by ensuring that roles and tasks align with members' abilities and interests. Teams that employ this strategy are likely to report greater efficiency and increased satisfaction with the project process. Additionally, students may gain valuable self-awareness and interpersonal skills that are transferable to future professional and academic endeavors.
Specific examples and adaptations of strength/asset mapping
• At the start of a design experience, encourage students to conduct structured appreciative interviews with team members, asking about each other's past successes, skills, and preferred ways of contributing, and develop a strength map for the team. This practice can cultivate mutual respect and allow the team to leverage individual strengths effectively. • Offer modular course components and/or design challenges, where students can select projects based on their individual asset maps. • Encourage students to maintain ***asset journals*** where they can document, organize, and analyze how their personal and cultural strengths influenced academic and learning activities.

Professional Dialogues

Professional dialogues is an asset-based interviewing-as-a-learning strategy that engages students in structured conversations with subject matter or community-based experts including thought leaders, end users, industry professionals, researchers, and other experts to deepen their understanding of real-world engineering practices and/or implications. This strategy facilitates active learning by encouraging students to co-design and ask questions, reflect on responses, and connect their design experience and courses to professional scenarios. Professional dialogues are based on experiential learning principles and emphasize the value of authentic, practice-oriented interactions [6], [14], [15], [16].

It aligns particularly well with design-focused courses, such as those emphasizing requirements engineering, where understanding stakeholder needs and perspectives is a critical component. Professional dialogues encourage students to practice eliciting stakeholder needs, analyzing requirements, and considering constraints in a manner that mirrors real-world engineering processes. These interactions can also foster professional identity formation by exposing students to diverse career paths and professional norms.

Table 3. Consolidated Implementation Guide for Professional Dialogue

How to implement professional dialogues?
To facilitate professional dialogues, educators can consider the following suggestions: • Identify and curate a list of experts/professionals from diverse backgrounds, including alumni, industry leaders, and community practitioners that align with the course objectives and students' interests. • Equip students with resources such as templates for designing interview questions and interview guide. • Encourage or require students to write reflective summaries or reports based on the dialogue(s).
Where are professional dialogues applicable?
Professional dialogues are particularly applicable in upper-level engineering courses that emphasize design, systems thinking, or interdisciplinary approaches. They are most impactful in project-based learning contexts such as capstone courses or collaborative design challenge, where understanding user needs, industry standards, and technological constraints is essential. Additionally, this strategy can support career exploration and professional skill development in other engineering courses.
What are some potential outcomes of professional dialogues for engineering students?
Professional dialogues can lead to numerous benefits for engineering students, including (a) enhanced communication skills, (b) better understanding of requirements engineering when deployed as a part of the design process, and (c) career awareness, when used in other core engineering courses.
Specific examples and adaptations of professional dialogues
• In team-based design courses, create opportunities for students to conduct a minimum of two interviews with customers or domain experts, early in the design process. In at least one of the interviews, students should be encouraged to use formal requirements elicitation tools as a part of the interviewing process. • In introductory engineering courses (e.g., first-year design; discipline-specific colloquia courses), provide specific themes for interviewing that align with the students' engineering major and community-centered topics such as material selection, sustainability, and user-centered design.

Appreciative Interaction

Appreciative interaction is a strength-based approach to communication that focuses on identifying and amplifying strengths within students, educators, and their shared learning environments (see Table 4 for implementation guide). It transforms routine exchanges—such as giving feedback as a part of assessment, advising, or mentoring—into meaningful opportunities for growth by embedding appreciation and inquiry into the communication process. This strategy is particularly valuable in engineering design education, where both individual skills and collaborative team dynamics play essential roles in project outcomes. Grounded in principles of Appreciative Inquiry [19] and Freirean pedagogy [20] , appreciative interaction emphasizes dialogue, co-creation, and the discovery of potential in every learner. For educators, it can serve as a framework to guide meaningful engagement with students while promoting inclusive learning and design environments. For students, it can foster self-efficacy, critical thinking, and the confidence to navigate engineering projects and design challenges.

Appreciative interaction has been shown to shift interactions into opportunities for mutual learning and development by prioritizing inquiry-driven dialogue and strength-based framing [5]. For example, a study of a postsecondary bridge program showed that appreciative inquiry fostered "hope-filled discourse" among adult learners with histories of academic disengagement [21]. This study highlights how the mechanism of appreciative interactions operates through a dual focus on *relational connectivity* (i.e., depth and quality of interpersonal connections within a learning environment) and *agentic storytelling* (i.e., the process of narrating one's experiences, strengths, and growth in a way that emphasizes personal agency and self-efficacy), allowing students to articulate how their relationships with educators and peers shaped their learning experiences and influenced their educational aspirations.

Appreciative interaction emphasizes acknowledging students' efforts and accomplishments while maintaining high expectations for their continued growth. Maintaining this balance between affirmation and high expectations can be strengthened through transparent instructional practices such as those outlined in Transparency in Learning and Teaching (TILT) framework [22], which suggests clearly communicating three aspects – *purpose*, *task*, and *criteria for success* – in assignments and learning activities [23]. TILT practices have been shown to improve student learning outcomes by demystifying expectations and reducing hidden barriers to achievement. Building on this foundation as well as research on stereotype threat [24], TILT principles can be adapted to enhance appreciative interaction by anchoring affirmations and feedback in the explicit learning goals and success criteria shared with students. In this approach, instructors first acknowledge students' efforts and achievements in relation to these transparent standards and then offer guidance that clearly articulates the next steps toward excellence.

Table 4. Consolidated Implementation Guide for Appreciative Interaction

How to implement appreciative interaction?
To facilitate appreciative interaction, educators can consider the following suggestions during the communication process: • Begin feedback by acknowledging students' efforts and recognizing specific successes. In other words, make explicit that feedback acknowledges and appreciates the effort that went into the task and then, channel that recognition into specific, constructive guidance for improvement. • Pose open-ended questions that can guide students in revealing their areas for growth. For example, "What aspects of your testing methodology could be refined to yield more reliable data?" • Pair constructive feedback with practical suggestions rooted in students' or team's existing strengths. Provide appreciative feedback iteratively at key project milestones or stages in the design process, allowing students to reflect and incorporate feedback into subsequent efforts.
Where is appreciative interaction applicable?
Appreciative interaction can be primarily applied when providing oral and written feedback as a part of team-based assessments (e.g., design reviews) and evaluation of any engineering

artifact. It can also be applied to individual academic advising and discussions as a part of career mentoring.
What are some potential outcomes of appreciative interaction for engineering students?
Aligned with Freirean pedagogy's emphasis on dialogue and critical reflection as tools for empowerment in education, appreciative interaction enables student teams to evaluate how their interactions and shared efforts contribute to project or design outcomes. It also encourages students to envision how their strengths can be applied to next steps in the design process and perhaps, even future challenges.
Specific examples and adaptations of appreciative interactions
• ***Appreciation Board:*** Establish a structured online discussion forum, using platforms such as Padlet, where students can reflect on their design project progress through an appreciative lens. Each week, students can share quotes, pictures, and/or additional content on a collaborative digital board to highlight a team member's strengths or a moment when a peer's insights positively impacted the project. • Implement a ***legacy document or letter*** initiative towards the end of a core engineering course where students can summarize key moments and suggestions for future students. This document can serve as a means to capture effective practices, promote continuous improvement, and allow future cohorts to benefit from the insights and successes of their predecessors. • As an alternative to or in conjunction with traditional peer evaluation in engineering design projects, implement an appreciative feedback protocol where students identify two to three strengths in each team member's work. This practice can facilitate a constructive feedback loop and lead to improved individual and collective performance.

Discussion and Limitations

The inventory presented in this manuscript reflects a curated selection of asset-based strategies that emerged organically through the scope and context of our project. While these strategies exemplify practical approaches grounded in our specific experiences and findings, they represent only a subset of the broader spectrum of asset-based methodologies that may exist. Other equally impactful strategies and frameworks, shaped by different contexts, disciplines, or pedagogical philosophies, are not captured here. Therefore, we encourage readers to consider not only the specific strategies shared here, but also the collaborative and contextual methods through which we identified these strategies, as a way of building upon and localizing asset-based strategies across engineering education settings. While each asset-based strategy can be implemented independently, they are also highly complementary and can be combined in several ways (see **Figure 2** for a demonstration) to support different phases of the design process. Depending on instructional goals and learning objectives, strategies may be sequenced, layered, or revisited over time to best fit the engineering education contexts.

Furthermore, the strategies outlined are not prescriptive but interpretive, offering one set of possible mechanisms for implementation. Variations in institutional resources, cultural environments, educator preferences, and student needs could lead to alternative interpretations or adaptations of these strategies. We consider this inventory as a living resource, one that can grow and evolve with continued exploration, experience, and the collective contributions of educators, students, and researchers in the future.

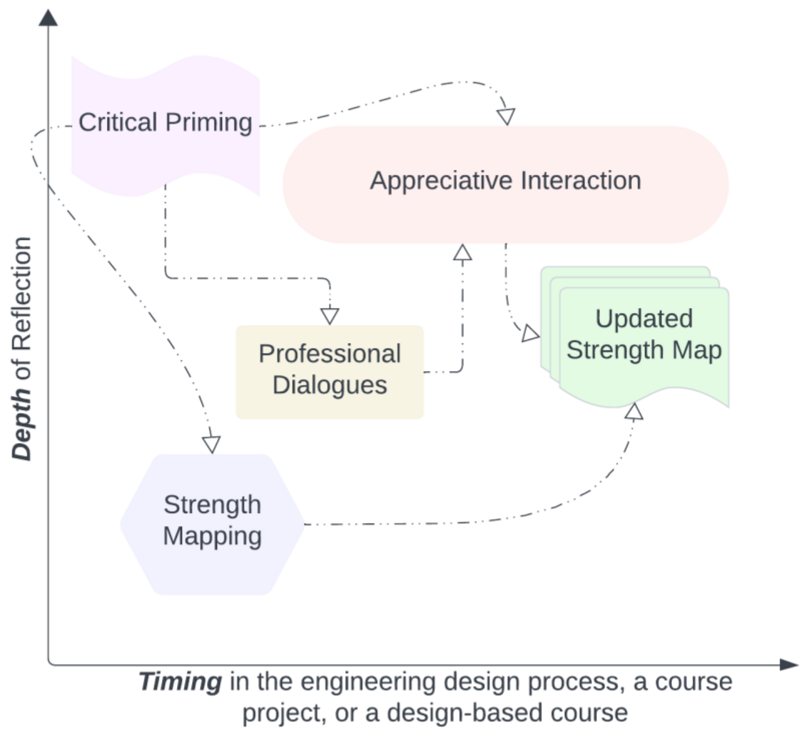

Figure 2. Demonstration of how selected asset-based strategies in the inventory can be conceptually organized based on two dimensions: timing in the engineering design process (early vs. late stages, represented on the x-axis) and depth of reflection (e.g., descriptive to transformative). ***Timing*** refers to where a strategy might most naturally fit within iterative phases of engineering design process, such as problem formulation, requirements elicitation, or verification. ***Depth of reflection*** describes the extent to which a strategy encourages students to move from simple description of experiences toward deeper critical analysis and transformative thinking. The relative placement and flow between strategies are arbitrary and intended for demonstration purposes only. In practice, a strategy's timing and reflective depth may vary based on course design, learning objectives, and/or implementation fidelity. For example, Critical Priming could be introduced both early and late in the design process, depending on whether the focus is on framing problems or critiquing solutions.

Conclusion

This manuscript introduces a first-of-its-kind inventory of asset-based strategies aimed at enhancing engineering education by fostering strengths-based practices that empower both students and educators. As the first version of this inventory, it represents a foundational effort to document and systematize strategies that promote self-efficacy, critical thinking, and collaborative problem-solving in engineering and design education. These strategies are designed to cultivate inclusive, reflective, and growth-oriented learning environments. The inventory is intended as a dynamic and evolving resource. As educators and researchers explore these strategies and adapt them to diverse contexts, new insights, applications, and even additional strategies are likely to emerge. The inventory, accompanied by an online implementation guide, will empower educators by providing accessible and practical tools and advance the uptake of the asset-based practices in engineering education.

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