Appreciative Inquiry as an Intervention for Equity-Centered Engineering Education Research and Praxis

1. Introduction

Appreciative Inquiry (APPI) is an asset-based research approach that has been used in a range of domains, including organizational development, public health, and education, to study and facilitate social change in organizations and communities [1], [2], [3]. APPI is grounded in social constructivist theory, which suggests that our perceptions of reality are socially constructed and that by focusing on positive stories and experiences, particularly from people whose identities are marginalized, we can create a more positive reality in work and learning environments [4]. Despite its prominence for over two decades, it is unknown to what extent APPI has been used in engineering education research. Further, there is limited to no evidence of utilizing APPI as an educational intervention.

1.1. APPI as a Research Methodology vs Intervention

As a part of an early-stage research project on evaluating the impact of asset-based practices in undergraduate engineering courses, we employed appreciative interviewing to elicit student experiences in applying their assets to projects and other learning activities in engineering courses. In recruiting interview participants, we strategically oversampled for marginalized racial/ethnic and gender identities to ensure diverse perspectives. During the interview process, we observed that student participants reflected on their strengths and connected them to their work in and beyond engineering courses, suggesting the potential of APPI to be used both as an asset-based pedagogical intervention and as a research method for collaborative sense-making with students about their experiences. We believe that students were able to better recognize and activate their assets because of APPI's roots in social constructivism, which enables participants to engage in collective inquiry and dialogue to reveal inherent, diverse strengths that may not be readily apparent in engineering contexts. Based on this observation, we sought to answer the following two questions:

(1) In what contexts has APPI previously been applied as a methodology in and beyond engineering education research, and how can it be extended to study as equity-centered practices? and

(2) How can APPI be employed as an educational or pedagogical intervention to value and activate student assets in engineering and engineering design courses? What lessons can be learned from the process?

To address these questions, we present a critical review of literature related to APPI followed by our specific approach to appreciative interviews in a research study related to asset-based practices.

2. Background

Appreciative Inquiry is often used as a themed methodology of conducting interviews [5], [6], [7] or focus groups [8], [9] and as an organizational change framework in higher education [8], [10], [11], [12], [13]. A preliminary search for APPI in the ASEE PEER database and a search for "engineering education AND appreciative inquiry" across abstracts, keywords, or titles on ProQuest databases yielded only around 37 results. Those studies that do discuss APPI primarily

reference the method for structuring interviews for data gathering [5], [6], [7]. The next most common use of APPI was as a framework for guiding organizational change in several educational contexts, including but not limited to, implementing new technologies [7], implementing new administrative practices across school districts [10], developing strategic goals to further student wellbeing [14], and recruiting or retaining faculty from minoritized backgrounds [11].

A few studies have used APPI to structure educational interventions such as developing team reflection skills [15], teaching students how to provide feedback as mentors [16], and structuring a feedback loop for continuous improvement [9], [12]. Two studies bordered on using APPI as both an intervention and a method of inquiry. For example, a study aimed at developing new pedagogical practices used APPI as a change agent for convincing faculty to engage in curricular development and gather data to monitor changes [17]. A more recent study used APPI to involve students in the creation of review and refresher materials [18]. Student reflections in this study indicated that APPI boosted their engagement in the learning process and made them feel valued in the curricular development process.

While there is limited to work in engineering education research or practice where APPI was explicitly used as an intervention, there is some evidence of APPI as an intervention in other domains such as management sciences, healthcare, and technical communication. For example, APPI was used as an intervention to promote team development as a part of project-based learning in an undergraduate organizational behavior course [19]. APPI was shown to have positive impact on team satisfaction and team processes, suggesting similar outcomes in engineering design education (e.g., improved design efficacy, enhanced communication). In healthcare, APPI has been used as an intervention to promote a variety of outcomes, ranging from improved knowledge among healthcare workers to changes in organizational practice. For example, a randomized controlled trial with an APPI-based intervention in a primary care setting showed positive behavioral changes and helped develop a shared vision and identity among participants [20]. In technical communication, Durá and team reported on using APPI, specifically appreciative interviews, as a food pedagogy intervention in a community after-school program for children and their families living in public housing on the U.S.-Mexico border. Durá's team chose appreciative interviewing as a way to honor community funds of knowledge [21]. As we discuss further in a later section, Durá's application of APPI was a model for our own adaptation in our work.

2.1. Appreciative Inquiry and Assed-based Approaches

Appreciative Inquiry is fundamentally a methodology for promoting social change in organizations. In addition to *social constructivism*, APPI is based on four other core principles [22] – *positive* principle (positive questions lead to positive change), principle of *simultaneity* (inquiry initiates change), *poetic* principle (the language of inquiry used in the inquiry process itself leads to significant outcomes), and *anticipatory* principle (human systems tend to move in the direction of their perception of the future) – all of which align with asset-based practices in multiple ways as demonstrated in Table 1 and Figure 1. In the following section, we argue that the theoretical bases for APPI and asset-based practices are complementary to each other, thus making APPI a useful research method as well as intervention in engineering education settings.

Table 1. Drawing parallels between APPI and asset-based practices

APPI Core Principles	Connection to Asset-based Practices
The **social constructionist principle** posits that reality is socially created through dialogue and shared understanding.	The social constructionist principle aligns with asset-based practices by recognizing that the collective construction of knowledge involves tapping into the diverse strengths and perspectives of all stakeholders (e.g., students, their families, and educators)
The **positive principle** suggests that promoting meaningful change in organizations and individuals requires substantial amounts of positivity.	Positivity is the core of asset-based practices. It emphasizes the identification and celebration of positive attributes, skills, and achievements.
The **principle of simultaneity** posits that the act of asking a question begins the process of change i.e., inquiry by itself an intervention.	Simultaneity aligns with asset-based practices by recognizing that (positive) changes can happen at any time. The process of inquiry can in fact activate inherent strengths in students and bring about new perspectives.
The **poetic principle** views organizations as constantly evolving narratives. It emphasizes storytelling, reflection, and the creation of a shared vision.	The poetic principle aligns with asset-based practices by recognizing the richness of students' stories and experiences and how it contributes to student outcomes.
The **anticipatory principle** involves envisioning and actively anticipating a positive future.	The anticipatory principle aligns with asset-based practices by focusing on the potential formation of professional identities among students. For instance, students' visions of their future careers or contributions to their fields can motivate their present learning and actions.

2.2. Theoretical Basis of APPI as an Asset-based Methodology and an Intervention

While social constructivism has already been discussed as a change mechanism, the *positive* principle also presents as a catalyst for student development. The positive principle posits that change is more easily achieved in an environment that supports and encourages it [23]. In an educational setting, APPI practitioners guide students in appreciative conversations as a form of soliciting and affirming their experiences and feedback. The focus on identifying strengths, including those stemming from minoritized identities, and discussing them, through conversation (i.e., APPI), affirms the value of those strengths. This affirmation process facilitates incorporating those strengths into engineering students' learning activities and identity formation. This positive principle is echoed in related concepts such as funds of knowledge [24] and community cultural wealth [25].

Building on the positive social narrative, the principle of *simultaneity* within APPI draws a student's attention to their inherent, diverse strengths [23]. Through directed reflection and inquiry, APPI encourages students to activate their inherent, diverse strengths by drawing deliberate attention to them. Simultaneity makes APPI as much an intervention (or an extension

of an intervention) as a method of inquiry since reflection on the meaning and goals of an educational intervention adds to the student's development process.

The *poetic* principle describes students as capable of telling ever evolving stories of themselves [23]. If students can narratively describe their experiences, the poetic principle says they can choose to find meaning and opportunities. APPI facilitates the identification of inherent, diverse strengths through asking the students to construct stories of how their strengths assist them.

The *anticipatory* principle states that anticipating a positive future can help students to make decisions that make that future a reality [23]. APPI encourages students to describe the positive ways in which others see them, in addition to interviewers affirming the student's inherent, diverse strengths (positivity). Thus, APPI helps students construct an internally and externally validated expectation of their future through stories themselves. Eventually, the image the student builds of their future will allow them to strive to achieve it by valuing their inherent, diverse strengths.

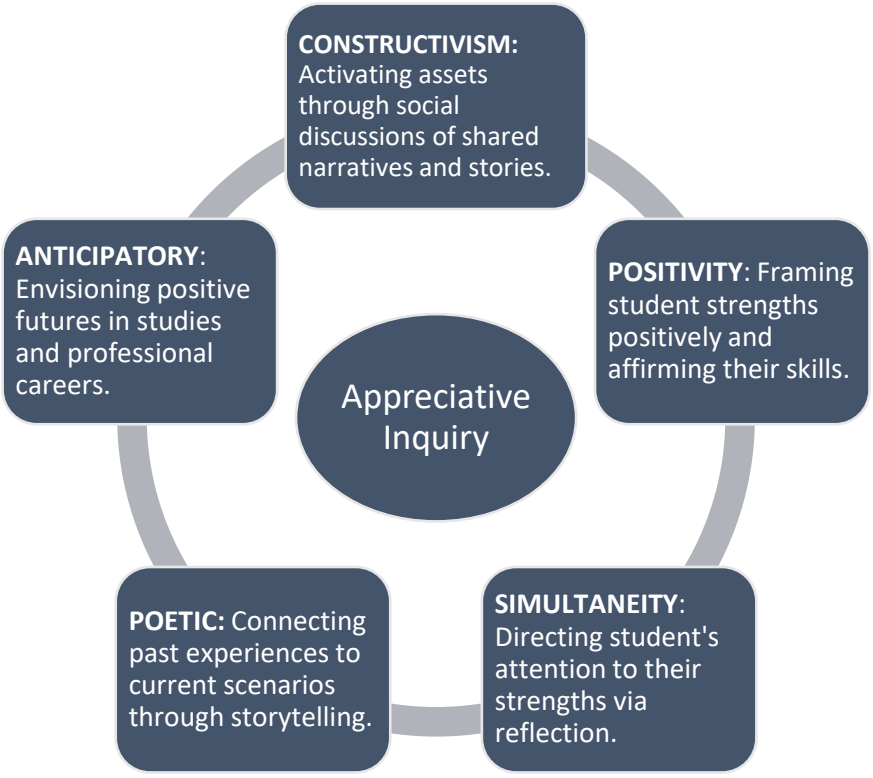

Figure 1: Core principles of appreciative inquiry and their impact on students' development when used as an intervention

When applied as a data gathering method and an intervention, APPI can encourage students to discuss the discovery and presence of their inherent, diverse strengths (assets). Thus, a student constructs and reflects on a narrative centered on asset discovery. Through *constructivism* and *simultaneity,* APPI can result in a student activating and internalizing the importance of those assets. When recording students' asset discovery process, facilitators employing APPI can frame students' skills in a positive light. Thus, after constructing and reflecting on their assets, students are encouraged to view those assets positively and in a way that is connected to their

experiences. The *positivity* principle and the *poetic* principle, respectively, proffer that this framing of constructed assets will drive students to adopt changes that feature these assets more prominently. Finally, by asking students to share stories of their assets in action and how others assign value to their assets, students construct a future image of themselves succeeding using their assets. The *anticipatory* principle encourages students to make the changes needed to achieve the image of the future they have constructed as a result of participating in APPI. The principles in-tandem form a developmental action plan that students construct, reflect on, affirm with help from a facilitator, connect to their past, and envision as a part of their future.

2.3. Applying APPI as a Methodology

The typical application steps of APPI as a method are *Discovery* (Initiate), *Dream* (Inquire), *Design* (Imagine), and *Delivery* (Innovate), referred to as 4D cycle [26], [27]. *Discovery* brings stakeholders of a system/organization together to identify positive moments through paired conversation. *Dream* analyzes positive moments to identify themes and construct a vision of the future of the system/organization. *Design* has students re-create or recontextualize their system/organization by proactively incorporating positive themes from the Dream phase. *Delivery* is acting on the redesigned system/organization plan developed in Design by changing behaviors or making an active effort to shift the status quo.

Using APPI as an intervention and data-gathering method in our context involves speaking to students who have experienced asset-based assignments in their engineering courses. These student participants walk through the typical stages of Dream, Discovery, Design, and to an extent, Delivery. Students reflect on their experiences with asset-based assignments by describing their experience of the assignment, their rationale for assets (inherent, diverse strengths) they identified, how their assets are present in daily engineering practice, and how they see their assets being a part of their engineering identity moving forward. This discussion is had between the student and an interviewer who is involved in the propagation of asset-based practices among faculty, both stakeholders that want to change the system (*Discovery*). Through further discussion with the interviewer, students identify themes and connect assets to their successes as engineers (*Dream*). Students identify ways in which their inherent, diverse strengths could contribute to their future success as an extrapolation of how these strengths aid them in gaining engineering skills in the present (*Design*). Students indirectly contribute to *Delivery* when they give permission for their asset-based activity work, their story, and/or their recommendations for future asset-based teaching practices to be shared with faculty participants in upcoming workshops intended to propagate asset-based practices across the curriculum. While students' direct contributions to *Delivery* are not actively tracked after the interviewing process, some students elect to share their stories with a broader audience so others can benefit from their stories during *Discovery* and incorporate more perspectives when looking for common themes with which to construct their vision of success (*Dream* and *Design*). This sharing is a step in *Delivery*, to change deficit-based practice to asset-based practice, as it adds to shared student knowledge and serves as an example of the benefits of asset-based practice for instructors.

3. Methods

3.1. Adapting and Applying APPI in a Mixed-methods Engineering Education Study

In this section, we contextualize our APPI application in the context of a mixed-methods study of asset-based pedagogies in engineering. Our APPI application is a qualitative component of a

larger, ongoing study that also includes a quantitative survey of students in classes wherein an asset-based pedagogy intervention [28] (e.g., an asset mapping activity) is implemented after the instructor participates in a professional development workshop offered by the research team. The qualitative component is a series of two one-on-one interviews with a small set of students (n=5 per semester) recruited via an optional question on the pre-survey. To enact an equity-centered approach to APPI, we use strategic sampling to prioritize student volunteers whose gender and/or race/ethnicities are underrepresented in engineering education. The interviews follow a similar pre- and post-structure at the beginning and end of the semester. We agree with Pawley's argument [29] that narrative-focused, small-n qualitative research with students whose gender and race/ethnicity identities are underrepresented in engineering is important and that it requires us to think differently about how we learn from individual stories. In addition to aligning with the asset-based orientation at the center of our project, APPI's core principles (as presented above in Table 1) offer a useful framework for both implementing and learning from small-n qualitative research. Specifically, APPI's core principles frame our qualitative interviewing as not only as an opportunity to contextualize students' experiences with asset-based pedagogy, but also as itself an asset-based intervention and an opportunity for co-designing pedagogical recommendations with students.

In our application, the APPI *social constructionist principle* guides us in situating the qualitative interviews as a space for the co-construction of knowledge with student participants. In other words, rather than attempting to extract an objective, generalizable truth from participants about their experiences, we recognize the interviews as an opportunity to learn from students' experiences and strengths and to collaborative with them on making sense of their experiences. Relatedly, the *positivity principle* and *simultaneity principle* guide our understanding of the interviews as themselves an asset-based intervention. The positivity principle connects our goals of advancing asset-based pedagogy in the classroom to our goals for the qualitative research component of the project: appreciative approaches can bring about positive change both in the classroom and in the research interview. The simultaneity principle reminds us that the way we invite students to share their experiences and strengths is an opportunity to affirm that students' experiences and strengths matter; the appreciative inquiry interview is itself an intervention.

The APPI *poetic principle* and *anticipatory principle* guide us in making sense of experiences and possibilities through narratives. The poetic principle reminds us that narratives matter and that they are dynamic and evolving, and this principle guides our application of narrative inquiry techniques to invite and collaborate on sensemaking through students' stories, as we discuss further below. The anticipatory principle draws our attention to future possibilities: as students make sense of past and present experiences through stories and dialogue about their strengths and experiences, they are also well-positioned to leverage and amplify their strengths in future interactions. Furthermore, by sharing their experiences and recommendations, students are imagining and enabling future change at the level of engineering pedagogy, and thus the anticipatory principle guides our incorporation of co-design prompts in the interviews. To contextualize and apply all APPI core principles, we use three different interview approaches in our study: (1) appreciative interview, (2) narrative inquiry, and (3) artifact-based interviewing.

3.2. The Role of Appreciative Interviews in our Study

As noted earlier, Durá's adaptation of APPI [30], specifically the appreciative interview for La Escuelita, a community after-school program for children and their families living in public housing on the U.S.-Mexico border, guided us in adapting and applying APPI as an intervention in an educational context. For Durá's team, appreciative interviewing was a way to honor community funds of knowledge [21] in the process of introducing and discussing "expert" knowledge on food pedagogies. Durá, drawing on resources from liberatingstructures.com, presents appreciative interview heuristic questions as follows:

1. "Tell a story about a time when you worked on a particular challenge and are proud of what you accomplished."
2. "Engage in sense-making about patterns for success and what made the success possible" (p. 30, numbering in original)

Durá then describes adaptations of the heuristic for the Escuelita program, where appreciative interviews were conducted in a group format, eliciting food stories shared first in pairs, then in groups of four, and finally in a large group discussion of insights. By foregrounding stories, Durá and colleagues aimed to "encourage the use of vivid details, concrete examples, and self-authoring of a strengths-based landscape" (p 30).

While our context shares a geographic similarity with Durá's application, and our research team shares Durá's commitment to honoring funds of knowledge and inviting stories as part of an asset-based approach, there are important differences in our respective contexts that shaped how we adapted and applied APPI. Our institutional context is a public research university with land grant and Hispanic-Serving Institution (HSI) designations. While the students in our study population share the experience of being in the engineering programs at the university, the university and its programs are not necessarily the source of assets and funds of knowledge that we seek to amplify in our approach. As a result, while Durá retained a focus group-style structure typical of appreciative interviewing, which has roots in organization and workplace settings [31], we chose instead to implement appreciative interviews in a one-on-one format. Since we were strategically oversampling students whose gender and race/ethnicity identities are underrepresented in engineering, we were concerned that a focus group format might impose a sense of presumed solidarity or sameness among participants.

An additional but related difference in our adaption of APPI is that while Durá's food pedagogy APPI implementation was part of a longer engagement in which the researcher and participants had already gotten to know each other, in our approach, the researchers are not involved in the participating classes and do not already know the students. Therefore, we stretch the two parts of the appreciative interview heuristic across a two-part interview structure over the course of a semester. In the first interview, we augment the appreciative inquiry heuristic with narrative inquiry approaches [32], [33]that align with the poetic principle of APPI and that allow us to get to know students by first inviting them to share their journey into engineering. To put it in terms of the APPI 4D cycle, the first interview creates space for the *Discover* phase**,** in which participants and researchers identify and appreciate positive moments [23], [31] – with the distinction that while APPI in organization and workplace settings tends to focus on positive moments within the organization or workplace, we intentionally expand the scope beyond the university setting to acknowledge students' funds of knowledge [21].

3.3. The Role of Narrative Inquiry in our Study

Narrative approaches have been used in engineering education research to invite and learn from the experiences of women and people of color through small-n qualitative research [29], [34]. Narrative inquiry, specifically, is an approach that arose in education research and that positions the narrator as a sense-maker [33]. In both prompting and analyzing stories, narrative inquiry attends to the ways in which storytelling "commonplaces" of temporality, sociality, and place contextualize and make sense of lived experiences [32], [33]. In other words, narrative is the unit of analysis, and it is itself an analysis. The initial stories we invite students to share function as a way of creating a shared understanding, or epistemic space [35], between the researcher and participant and as a way of contextualizing our adaptation of the appreciative interview prompt. After learning about students' journeys into engineering and noting with them strengths and successes along the way (in accordance with APPI's positivity principle), the researcher then moves to the first part of the appreciative interview heuristic, inviting the participant to share about a time when they successfully navigated an engineering challenge (in or outside of the classroom). The telling and initial discussion of a success story anchor the first interview.

3.4. The Role of Artifact-based Interviews in our Study

We also augment the appreciative interview heuristic with artifact-based interviewing to contextualize students' experiences with the asset-based pedagogy implementation in the class from which they were recruited. In either the first or second interview, depending on when the instructor implements the asset-based pedagogy activity (such as asset mapping), we invite students to share and discuss what they created in the class activity. When the first interview occurs before the asset-based pedagogy activity, the success story students share in the interview functions as a potential starting point for their asset map. When the first interview occurs after the asset-based pedagogy activity, the success story is an opportunity to elaborate on an item in the asset map. And when there is not an explicit asset-based pedagogy activity in the class (as was the case in our first semester of interviews), the artifact-based interviewing shifts to a discussion of student-identified opportunities to showcase their strengths in the class. The artifact-based interviewing component sets the stage for the *dream* component of the 4D cycle, or envisioning results [23], [31], as we prompt students to imagine how they might revisit or draw on their asset maps in the future.

3.5. Author and Team Positionality

Like other engineering education researchers conducting qualitative research with students whose gender and/or race/ethnicity identities are minoritized in engineering, we believe it is important to account not only for the self-described background of the participants, but also for interviewer positionalities [29], [34], [36], because our positionalities are inextricably linked to power dynamics that shape every aspect of qualitative research, from study design, to participation, to interpretation. ASM, a member of the research team and lead author, conducted the interviews, along with GP. ASM is white woman who uses she or they pronouns. She is a tenured associate professor of English specializing in equity-centered design research and technical communication. ASM conducted all of the first-round interviews. For the second interviews, ASM was joined by GP, a postdoctoral researcher who joined the research team in Fall 2023. GP is a south-Asian male who uses he/him pronouns. He is a postdoctoral fellow specializing in mixed-methods research for sociotechnical systems assessment and engineering education studies. HDB, principal investigator for the overall project, is a White woman with mechanical engineering background and expertise in engineering design. In addition to her

engineering education research, she has rich teaching experience at three HSIs in the state of Arizona, learning from and with students from a diverse range of backgrounds and interests. FL is a Hispanic woman and educational psychologist by training. She spent her formative years in Texas and the borderlands as a bilingual teacher and at-risk high school counselor, which shaped her professional and research interests in teacher beliefs, teacher expectations, and educational policies. FL is an expert in equity pedagogy, including asset-based practices. VS is a cisgender, south-Asian male with background in biomedical and computer engineering. He is actively involved in HSI scholarship and initiatives, including place-based educational programs. All authors have served or currently serve at public, land-grant, HSIs.

Interview participants described their race/ethnicity identities and gender identities in optional questions in the first survey (which included multi-select options, options to not disclose, and open-ended options to self-describe). The student interview participants' self-described identities, pronouns, and pseudonyms (via the recruitment survey and interview conversations) are as follows:

- C uses he/him pronouns and identifies as a Hispanic/Latinx man. C is a senior civil engineering major.
- Hawk uses she/her pronouns and identifies as an Asian/Asian American woman. Hawk is a second-year biomedical engineering major. Hawk further self-described in the interview as an international student.
- Joe uses he/him pronouns and identifies as a white man. Joe further self-described in the interview as a first-generation college student who had experienced houselessness growing up. Joe is a first-year PhD student in civil engineering who recently completed an undergraduate degree in civil engineering at the same university.
- Limón uses he/him pronouns and identifies as an African American/Black man. Limón is a second-year biomedical engineering major.
- Orion uses she/they pronouns and identifies as woman and as non-binary and genderqueer/gender-nonconforming. Orion identifies as white and is a second-year biomedical engineering major.

3.6. Summary of Interview Protocols

In Table 2 below, we share our semi-structured interview protocol for the first interview, connecting the questions to the specific interview approach we are using and the APPI 4D cycle phases we are engaging:

Table 2. Interview Protocol - Part I

Question	Interview Approach/ APPI 4D Cycle
Tell me about yourself and your journey to becoming an engineer: • When did you know you wanted to be an engineer, and why? • Who supported you along the way? • How did you choose this institution/major? • Where are you in your studies? What's your experience been like? • What are your goals for the future?	Narrative inquiry APPI Phase: *Discover*

Have you worked on an asset map activity [or other asset-based pedagogy activity] in your class? If so, would you mind sharing it? • Talk us through the activity instructions and your map. • When and how was it assigned? • How did you complete it? Did you get help from classmates or friends/family? • What was the experience like for you? • Is this something you imagine revisiting or doing again on your own? Why or why not?	Artifact-based interviewing and narrative inquiry APPI Phase: *Discover* and *Dream*
[If they have not done the activity] If you were asked to list your strengths and assets as an engineer, what would you include?	Appreciative interviewing APPI Phase: *Discover*
Tell me about a time when you did something you consider engineering-related (in or outside of school) and you were proud of it [if they have done the asset map, it could be an illustration of an item on the map] • When was it? • Who was involved? • How did you do it? • How did you feel?	Appreciative interviewing APPI Phase: *Discover*
[The interview concludes with the researcher previewing the next interview discussion, which includes revisiting, reflecting on, and adding to this conversation.]	Equity-centered co-design and appreciative interviewing APPI Phase: *Dream*

The second interview continues the appreciative interview heuristic, revisiting the success story (and, if applicable, the asset mapping activity experience) shared in the first interview and then engaging in collaborative sense-making of the story, as indicated in the second prompt of the APPI heuristic. In our approach to collaborative sense-making, we are guided by APPI's social constructionist and simultaneity principles, as well as by Koelsch's call [37]to reframe the member check (the step in which researchers ask participants to review how their data has been recorded and/or interpreted) as part of the data collection and analysis process, rather than as a perfunctory and often-optional step after the formal interview. In a similar argument, Alsup calls for "transformative data analysis" [38] with participants and argues that it is an important accountability and reciprocity practice in justice-focused education research.

We blend transformative data analysis and the appreciative interview heuristic's collaborative sense-making prompt by sharing a notes file with the participant (housed in our institution's password-protected Box drive system) that includes researcher notes and links to interview transcripts. Students can edit the files themselves or verbally comment on or request changes and additions. Furthermore, in recognition of the students' ownership of what they shared and in the hopes that they may be able to use the information for their own purposes (such as preparing

applications or interview responses), the students retain access to and editing control of their notes file for the duration of the study, after which they will be encouraged to make their own copy, if they wish, before the information is deleted. In this way, we enact the *Design* component of the 4D cycle, in which participants and researchers co-construct positive change drawing on the *Discover* and *Dream* phases [23], [31]. In our case, the most immediate scope of designing positive change is in students' own agentive uses of the artifacts of their participation in the study (including the asset map they produced in the class and the shared notes. Indirectly, and according to students' preferences shared during the interview process, the scope of designing positive change can also include future iterations of the qualitative research, informed by student insights and stories, and, as we discuss next, future iterations and implementations of asset-based pedagogy that incorporate students' stories and recommendations with their permission.

Therefore, to embrace designing positive change at the level of asset-based pedagogy, we also supplement the appreciative interview heuristic in the second interview with questions that enact equity-centered co-design [39], imaging and enabling future possibilities for students' own experiences and for asset-based pedagogy. Broadly, equity-centered co-design asks researchers to center the experiences of participants by considering

- "What are the steps that can be taken immediately following a design engagement such that the impact is immediately perceived?" and
- "What are the resources that already exist and can be leveraged and supported, such that they are able to be maintained and progressed in the absence of researchers [39].

These equity-centered co-design considerations connect to the APPI anticipatory (future-oriented) principle and bridge the *Design* (co-constructing) and *Delivery* (sustaining) phases of the 4D APPI cycle [23], [31]. In our case, this looks like having a conversation with student participants about how we are learning from and acting on what they have shared in our immediate context, as well as our plans for contributing to engineering education research more broadly. We explain that they have continuing access to the notes and transcripts from their interview which they can revisit and potentially use for their own purposes, and we also explain how their input can inform upcoming professional development workshops for engineering instructors in our community. We ask if we can follow up for written permission to use quotes or artifacts (such as asset maps shared) in the workshops, according to students' preferences. We also invite students to identify existing resources—including those outside of the classroom—for appreciating and cultivating students' strengths (e.g., thus far, students have mentioned peer-mentoring programs and supportive academic advisors). We incorporate those resources in our own understanding of and presentations of the asset-based pedagogy landscape in our conversations with faculty.

In Table 3 below, we share our semi-structured interview protocol for the second interview, again connecting the questions to the specific interview approach we are using and the APPI 4D cycle phases we are engaging:

Table 3. Interview Protocol - Part II

Question	Interview Approach/ APPI 4D Cycle

[If the asset map activity happened between the first and second interviews] Have you worked on an asset map activity in your class? If so, do you mind sharing it? • Talk me through the activity instructions and your map. • When and how was it assigned? • How did you complete the activity? Did you get help from classmates or friends/family? • What was the experience like for you? • Is this something you imagine revisiting or doing again on your own? Why or why not? • What recommendations would you have for instructors thinking about including an activity like this?	Artifact-based interviewing, narrative inquiry, and equity-centered co-design APPI Phase: *Discover*, *Dream*, and *Design*
[If the asset map activity happened before the first interview and was already discussed]: In our previous conversation, we talked about the asset map you made earlier in the semester. [Revisit specific details.] Do you have any thoughts to share about that experience now, looking back on it? • Is there anything you would add to the map now? • Is there anything you would do differently if you were making an asset map now? • Is this something you imagine revisiting or doing again on your own? Why or why not? • What recommendations would you have for instructors thinking about including an activity like this?	Artifact-based interviewing, narrative inquiry, and equity-centered co-design APPI Phase: *Discover*, *Dream*, and *Design*
[If there was not an asset map activity or other explicit ABP experience] Were there assignments, interactions, or resources that gave you an opportunity to highlight what you bring to engineering? • When was it, and how did it fit into the class overall? • Who was involved? • How did it go? • What was it like? • What recommendations would you have for instructors about ways to highlight students' strengths?	Artifact-based interviewing, narrative inquiry, and equity-centered co-design APPI Phase: *Discover*, *Dream*, and *Design*
Thinking beyond this activity or class, are there other resources in or outside the engineering program that support you in highlighting your strengths?	Appreciative interviewing APPI Phase: *Discover* and *Delivery*
Revisiting strengths and stories from the first conversation [review notes and transcript]: is there anything you'd like to add, revise, or expand on?	Appreciative interviewing APPI Phase: *Discover* and *Dream*
Can we follow up with you about including quotes and/or your asset map in future professional development workshops for instructors?	Equity-centered co-design

[The interview concludes with the researcher reminding students about their shared access to the notes and transcripts and describing next steps, including plans to contact participants via email for quote permissions and with updates on study publications and timelines.]	APPI Phase: *Design* and *Delivery*

In the next section, we share how we implemented these protocols and what we learned in the most recent implementation semester of our project.

4. Results

4.1. Processes and Lessons from Applying APPI

In Fall 2023 implementation, two instructors agreed to survey and allow interview recruitment in their respective classes, and a third instructor agreed to the survey and interview recruitment for the following semester, which is currently in progress at the time of writing. Student interview participants were recruited via the pre-survey in a 200-level biomedical engineering course and in a 400/500 (co-convened undergraduate and graduate) civil engineering course. The research team decided to keep the total number of recruits at five and strategically sampled across both classes. Our goals were to continue to prioritize students who identify as women, nonbinary, transgender, and/or genderqueer/gender-nonconforming and students who identity as people of color, as well as different engineering majors. There were only two volunteers from the civil engineering class, so we recruited both. We recruited three students from 18 total volunteers in the biomedical engineering class, prioritizing people whose gender and/or race/ethnicity identities are underrepresented in engineering, broadly, and in our study, specifically. All five recruits from the two classes agreed and participated in two interviews. They were compensated $20 in cash for the first interview and $30 in cash for the second interview.

The first interviews took place across a one-week period in mid-September, and all first-round interviews occurred before the asset-based pedagogy intervention (an asset mapping activity) took place in the respective classes. All first-round and second-round interviews were conducted and recorded on Zoom, lasting no longer than an hour each, with mailed cash payments (all confirmed received) and electronically signed consent and payment forms. In the first interviews, following the semi-structured protocol described in the previous section, the researcher invited students to share about themselves, their journey to and experiences in engineering, and their strengths and successes as engineers. The interview concluded with the researcher previewing the structure of the second interview.

The second interviews took place across a two-week period in late November and early December, during the last week of classes and finals week. During the scheduling process, we let students know that we would like to see and hear about their asset map activity as part of the conversation, if they felt comfortable. All students discussed their asset map activity, and four of the five shared a digital copy of their asset map via screensharing and/or email. (The fifth student verbally described the asset map.) We also shared a notes file (with links to transcripts) with each student to revisit students' stories and review, add, or update the notes and transcript. Limón reflected on stories illustrating his metacognitive awareness, or "thinking about how I think," and the unique perspective he brings to problem-solving. Hawk shared and expanded on stories about how she "puts the human first" and "manifests connections" with others. Orion shared past and present stories about creative, "outside of the box" solutions to design challenges, noting that

even when they felt like they lacked experience compared to their peers, they made up for it by being a "dreamer not crushed by reality," able to generate ideas for feedback. C reflected on a story about how facing adversity and personal loss had given him clarity and a sense of purpose, and he celebrated accepting a post-graduation job at an engineering and design firm. Joe shared and reflected on stories illustrating his strength in and affinity for deliverable-oriented work, even as he grappled with challenges accompanying his transition from an undergraduate to a PhD student in his lab.

In sharing about the broader landscape of resources for highlighting strengths, two students mentioned their supportive academic advisor in biomedical engineering, who encourages students to join clubs and connect with opportunities. Limón valued the experience of pursuing biomedical engineering as a pre-medicine major along with a minor in health and human values, encouraging him to think about ethics in design (and vice versa) and introducing valuable reflection activities. Hawk described an engineering leadership themed housing community she lived in during her first year, where the advice to create a LinkedIn has served her well in networking over the years. Beyond the university, Hawk described networking with other women at the Society of Women Engineers conference, as well as on LinkedIn.

In pedagogy co-design discussions, students connected the asset map activity with a more general practice of reflection, which they saw as valuable even if they did not envision revisiting the asset map they created in the class activity. Limón was the only participant who envisioned directly building on his asset map (which he built in MATLAB) over the semesters and years, but other students, including C, Orion, and Hawk emphasized the value of identifying and reflecting on strengths over time—either individually or in other class activities. Orion and Hawk both recommended having asset map activities across the engineering curriculum. As Hawk explained,

> *"These [asset maps] are almost like reflections. So, if we do it at the end of each semester, these are basically reflections for what we've done each semester, and I think reflecting is a really good habit to have, because it helps us acknowledge how much effort [we've given] and how far we've come. I'm sure there was a time at the beginning of the semester when everyone thought they wouldn't be able to do things. But then, surprisingly, at the end of the semester, you've accomplished far more than you could have thought of at the beginning. So if we take some time to reflect and make this asset map at the end of each semester, I think that would be really nice--just tracking how much progress we've made."*

We plan to share these recommendations and sample asset maps (with student permission), as well as students' accounts of broader resource landscapes for appreciating assets, in future professional development workshops to help instructors envision how students might approach the activity in different courses and to encourage all of us to think about how asset-based activities such as the asset map could connect with other resources and/or scale up to support students' experiences across and beyond the curriculum.

4.2. Scaling APPI

Existing examples of APPI are often narrow in scope, typically with one-on-one or small focus group formats. Engineering instructors can engage in these discussions in office hours or drop-in

sessions, but there is limited opportunity to talk one-on-one with students beyond such settings. To scale APPI, we must find ways to incorporate elements of APPI to typical undergraduate engineering courses, where one instructor interacts with dozens (or many dozens) of students at once. Existing literature provides an example of using APPI in a scalable way, where APPI was used to provide constructive, positive feedback from an instructor to students or vice versa [9], [40].

- Instructors can incorporate an APPI lens into the feedback they give students on assignments and other learning activities, especially as a part of formative assessment.
- Another possibility is to redesign course activities to incorporate APPI, structuring reflection opportunities into the curriculum (e.g., assignments with an element of storytelling about how a student explored a topic or learned a new skill).
- We can also redesign our course activities to be more grounded in and connected to students' lived experiences, so they can easily connect course material with their existing identities and skills (e.g., design projects that draw on their knowledge or experience from personal or family life).
- Finally, we must seek to broaden the number of individuals who can apply APPI to support students. As we attempt in this project, faculty professional development can expand the impact of APPI to entire programs, departments, or colleges. Also, students themselves can act as peer mentors, and advising staff can also be leveraged to facilitate opportunities for positive storytelling and strength-based discussions of students' educational journeys.

5. Conclusion

Discipline-based educational research often begins with researchers identifying a problem that needs to be addressed or solved within their disciplinary contexts. Recent educational scholarship has begun to move away from deficit framings of marginalized students, although deficit mindsets still dominate society's view of educational achievement [41]. In the past decade, new frameworks have been proposed (e.g., Harper's anti-deficit achievement framework [42]) to reframe research questions in an anti-deficit way. Kolluri & Tichavakunda [41] cite a specific example of Harper's framework: rather than asking "Why do so few Black male students enroll in college?", an asset-focused research question could state "How were college aspirations cultivated among Black male undergraduates who are currently enrolled?" [42].

While this focus on assets instead of deficits has come to take hold in the broader education research community, the "dominant discourse in engineering education" still often focuses on the perceived "inadequacies" of students of color [43]. Scholars have called for greater diversity in the research methods and theoretical frameworks employed in discipline-based educational research to help frame and design research studies that challenge deficit models and instead focus on the assets of marginalized students [44]. We posit that equity-centered methodologies such as APPI, which emphasize strengths and positive narratives, are critical for not only enriching engineering education research methods, but also for promoting asset-based practices and ultimately, advancing educational equity. Our work validates the core principle of APPI that **inquiry is intervention** and serves to demonstrate the application of APPI as an asset-based educational intervention in engineering contexts.

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