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PRACTICE

Contemporary Issues in Practitioner Education

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rpra20

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PRACTICE
https://doi.org/10.1080/25783858.2024.2424218

Development and application of the Scripted Animation Survey (SAS) for out-of-school time professional learning

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ABSTRACT

Despite the wealth of learning youth experience outside formal classrooms, relatively little research has been invested in understanding out-of-school-time (OST) educators' professional learning (PL). We explore this need in the context of a STEM facilitation PL program (i.e. Afterschool Coaching for Reflective Educators in STEM, or ACRES) through their foundational PL module, Asking Purposeful Questions, by describing the development and use of the scripted animation survey (SAS) using the framework of educator noticing. First, we detail how we developed and validated an analysis approach to the SAS. Through iterative development with feedback from PL providers, we identified a delivery format; response process; and codebook that aligned with the program objectives and paralleled the feedback exchange structure familiar to participating educators. Second, we apply the educator noticing framework to illustrate a possible use of the SAS. In comparing pre- and post-administration of the SAS using the noticing framework, we identified a shift in respondents' noticing to be more aware of youth activity relative to educator activity. We suggest that the SAS may be a useful tool to diagnose and respond to educator attention within a PL program, particularly when logistical and financial constraints restrict access to longitudinal videos of practice and interviews.

ARTICLE HISTORY
Received 2 April 2024
Accepted 6 October 2024

KEYWORDS
Out-of-school time; OST education; STEM facilitation; virtual professional learning; instrument development

While much science learning and appreciation of STEM in the United States (U. S.) occurs outside of the K-12 classroom (Stevens *et al*. 2005, Falk and Dierking 2010, Peterson 2013), professional learning (PL) for U.S. out-of-school (OST) STEM educators is largely absent or, when available, limited in breadth, depth, and accessibility (Brasili and Allen 2019, Shea *et al.* 2023). This restricted access intensifies the difficulties of aiding OST educators to hone their STEM facilitation skills (National Research Council 2015) and acquire credentials that institutionally legitimise their expertise (Shea *et al.* 2023), compared to the opportunities that exist for formal educators who more readily have temporal, geographical, and financial access to PL.

Since 2016, our non-profit organisation, MMSA has addressed this need by providing high-quality, virtual PL for OST educators across the U.S. through *Afterschool Coaching for Reflective Educators in STEM*, or *ACRES*. ACRES offers

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seven modules of STEM facilitation skills as part of its PL catalogue, including 'Facilitating Science practises' and 'Make Math Engaging'. The purpose of the ACRES program is

> Building knowledge and skills so afterschool educators, librarians, and anyone who works with youth in out-of-school settings can confidently facilitate science, technology, engineering, and math (STEM) experiences for youth. (acrescoaching.org)

Each ACRES 'cohort' consists of five to seven OST educators who meet for three virtual, synchronous Zoom sessions, distributed over several weeks to accommodate educator schedules. Between each session, participating educators record themselves practising the target skill – ideally a video with audio and visual capture – to share at the following meeting.

Educators are encouraged to begin their PL with the foundational module 'Asking Purposeful Questions in STEM' (APQ). This recommendation is based on evidence suggesting APQ sets a foundation upon which other inclusive STEM facilitation skills can be built, such as fostering respectful and inclusive dialogue where all youth can share their expertise and take charge of their learning (Afterschool Alliance 2015, Michaels and O'Connor 2015, Busch *et al.* 2023). The skill of APQ and the goal of the module are illustrated in Figure 1. In the first meeting, coaches ground this goal by (a) defining purposeful questioning; (b) outlining a process for APQ; (c) facilitating discussion using videos of educators practising APQ in OST; and (d) sharing a handout with a list of broadly applicable purposeful questions (e.g. 'How did you arrive at that conclusion?') (see resources at acrescoaching.org).

ACRES's model cultivates reflection and learning through activities that support and build from *educator noticing* (van Es and Sherin 2002) of a target skill (e.g. APQ) in practise. In the context of APQ, educators (1) attend to the use of APQ in evidence of practise shared by peers; (2) apply ideas from the PL program and personal experience to reflect on the shared practise; and (3) draw connections to comment on the peer's use of APQ (see Figure 2). Coaches structure these feedback sessions by asking educators to share these connections by voicing a 'strength' and 'opportunity for growth' related to APQ.

Goals
Questions are the beginning of a path towards discovery, imagination, and STEM exploration. 'Purposeful' questions are well-placed questions that help youth expand and clarify their thinking, develop their reasoning and navigate science and engineering experiences with sharpened intentionality and focus. ***The learning goal for this ACRES Module is for educators to be able to use well-placed questions to facilitate STEM learning and help learners understand what they should focus on and where they should go next.***

Figure 1. The goals of the APQ module are indicated in this excerpt from the coaching manual.

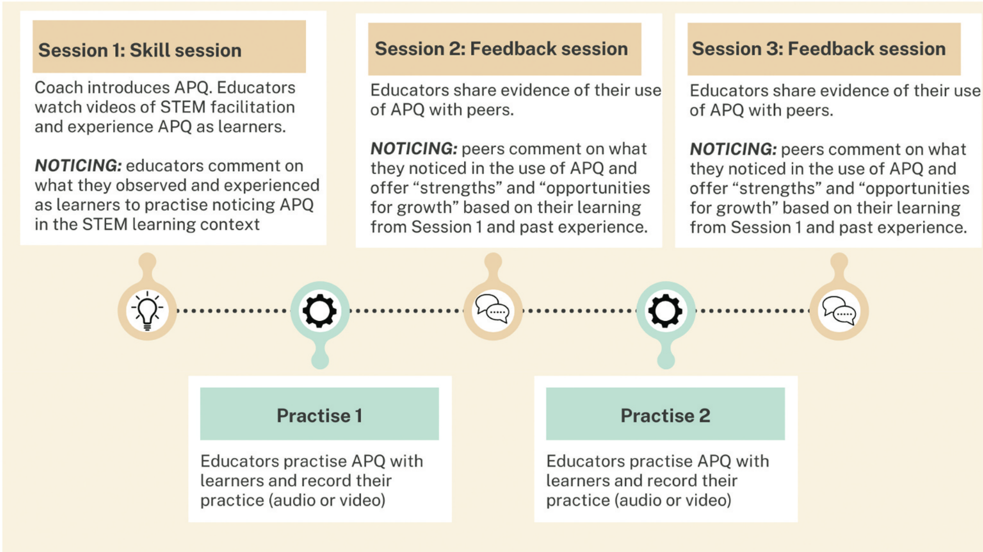

Figure 2. The sequence of sessions that educators experience in the APQ module. Boxes at the top indicate synchronous sessions held virtually over zoom. The boxes on the bottom indicate work that educators do outside of the sessions.

Recognising the need for PL assessment tools

Although ACRES originally focused on having its own coaches support educators nationwide, it has recently expanded by training external 'hub' coaches to deliver ACRES PL in their local regions. In collaborating with these coaches, we identified a widespread need for accessible, easy-to-interpret assessment tools that coaches could use to monitor how educators recognise the PL skills in practise. In response to this need, we collaborated with MMSA coaches to design an assessment tool, the *Scripted Animation Survey* (*SAS*).

In the present manuscript, we explore the development and use of the SAS through two research objectives. *First*, we present the development of the SAS, focusing on (a) format (e.g. multiple-choice, open-ended); (b) content; and (c) analytical opportunities. Our first research question is: *What are the characteristics of an assessment tool that can measure OST educator growth from participating in a virtual PL program? Additionally*, we illustrate the use of the SAS to explore the desired outcomes of a PL by evaluating *pre/post* changes using the framework of educator noticing (van Es and Sherin 2008). More specifically, we consider how and to what extent noticing shifts between educator-centric, classroom-centric, and youth-centric foci between *pre* and *post* administration of the SAS. Our *second research question* is: *What changes are observed in the focus of OST educator noticing between* pre *and* post *administration of the SAS?* This aligns with the foundations of the ACRES program, which are based on an awareness that APQ as a facilitation tactic can decentre educator ownership of STEM, allowing STEM knowledge construction to be developed through youth-youth or youth-educator collaboration.

Background and theoretical basis: educator noticing

Since ACRES sessions support reflection on evidence of practise that educators contribute – typically in the form of videos of STEM facilitation with program youth – we first describe how video formats support noticing. Then, we discuss existing efforts to measure educator noticing, situating our efforts within the SAS in that literature.

Educator noticing using video reflection

Researchers have discussed *noticing*–or 'the act of focusing attention on and making sense of situation features in a visually complex world' (Jacobs and Spangler 2017, p. 771, cited in Amador *et al.* 2021) – as a fundamental step in learning across contexts. For instance, Lobato *et al.* (2012) explored student mathematics learning using noticing as a way to frame students' activity in 'selecting, interpreting, and working with particular mathematical features or regularities when multiple sources of information compete for students' attention' (p. 438). Hanna *et al.* (2014) used noticing to understand knowledge and skill transfer for farmer production. These studies share an acknowledgement that what draws a learner's attention – i.e. what they 'notice' – has ripple effects on subsequent learning that builds on the initial noticing.

Educator noticing, popularised in mathematics education, recognises the social and contextual complexities of teaching. Educators engage in *noticing* when they (a) attend to some phenomenon in the learning environment, (b) draw from their training to think about the phenomenon, and (c) apply that training to the specific phenomenon at hand (van Es and Sherin 2002). Conceived initially to refer to how educators make in-the-moment observations and assessments to respond to perceptions in their classrooms during teaching, researchers have since taken up the construct to explore a variety of educator cognitive activities, including reflection on their own and others' teaching (Chan *et al.* 2021).

PL providers have long adopted video-based reflection as a component of their interventions due to its ability to support educators' awareness of classroom activity that may be difficult to perceive while actively teaching; its possibilities for viewing unique educational contexts for critical reflection on personal choices; and its affordances for creating a shared entry-point for conversations within a community of practise (Clarke and Hollingsworth 2002). In this way, videos are highly suitable for noticing and reflecting *after* the in-the-moment teaching observations, especially with the joint contributions of teacher educators and peers (Prilop *et al.* 2020). A summary of work produced by Sherin and colleagues, cited in Star and Strickland (2008), suggests that participation in PL that involves viewing and reflecting on videos of practise is associated with attention shifts, from noticing of teacher action to more awareness of student participation.

Measuring educator noticing

Given the associations between noticing and desired educator development outcomes, researchers have explored approaches to *assess* noticing, as evidenced by two recent synthesis studies. Amador *et al.* (2021) evaluated methodological choices in studying mathematics preservice teacher (PST) noticing – a popular focal population given the origins of noticing in mathematics education and the relative ease for university-affiliated researchers to study PST development through researcher-delivered coursework. Their review of 27 publications indicated that researchers typically collected noticing data using written reflections or a combination of written reflections and transcripts (e.g. of an interview). Such formats make sense for studying PSTs, who develop within a structure where writing assignments and conversations with the researcher (typically also the course professor) fit within coursework routines. Thus, the scope of their work does not include populations that may not have the structure of a teacher education classroom. Further, while their analysis included coding for 'artifacts of intervention' or 'what the participants took part in (e.g. videocase, coursework)' (p. 4), their analysis did not directly consider the role of these artefacts in educator noticing. Thus, it is unclear from their review if there is a preferred data collection format for noticing context (e.g. if open-ended questions are particularly suited to measuring noticing from a video case study).

Weyers *et al.* (2023) review included assessments of noticing across subject areas and educator experience. Yet, their summary further illustrates the preponderance of attention to PST education – with PSTs included in 28 of reviewed studies ($N = 37$). While Amador *et al.* (2021) focused on methodology – including identifying the *type* of data collection tool – Weyers and colleagues specifically focused on *assessment tool 'validity'*–or the 'degree to which evidence and theory support the interpretations of test scores for proposed uses of the tests' (APA, NCME, and AERA 2014, cited in, p. 11, Weyers *et al.* 2023). The authors acknowledge the existence of more modern 'unitary' constructions of validity (ibid.); however, they organised their work within older – but still highly cited – ways of supporting test validity: (1) content validity, or the adequacy of the items to measure the construct; (2) criterion-related validity, or the adequacy of the test results to predict related measures; and (3) construct validity, or the sufficient correlation between the test score and theoretically related measures (Cronbach and Meehl 1955, cited in, Weyers *et al.* 2023). Using this framework, they noted that researchers rarely provided validity evidence for noticing assessments. Among their reviewed studies with validity evidence, content validity was most commonly cited (in 14 instruments), typically using expert review, followed by construct validity (8 instruments), typically using factor analysis or item response theory modeling. Most research included in their analysis relied on videos of authentic classroom practise to elicit noticing responses, and the plurality used open-response item types that are scored using a coding framework. This preference for open-ended responses is likely consistent with Amador *et al.* (2021) findings that indicated researchers favoring 'written documentation'.

The opportunity and need for noticing instrument validation

The two reviews expose the need for further research that (a) extends beyond the PST context, and (b) grounds the validity of assessment tools in particular contexts of educator population – building on updated guidance of unitary concepts of validity. We address both of these opportunities in our work to assess OST educator noticing in the context of ACRES.

We see this attention as an important addition to the noticing literature in two ways. One, the current preponderance of research on developing teachers in university classrooms (i.e. PSTs) leaves unaddressed the unique complexities of noticing that takes in OST settings that generally do not have set curricula; are primarily comprised of an educator community that exercises teaching expertise acquired outside of a teacher education program; and supports learning in a transitory youth population. Understanding educator noticing here could illustrate how noticing may be cultivated in programs with unique contextual complexities not reflected in the existing literature. Further, providing a tool that is usable by PL providers could support OST PL providers who often have not received investment from research institutions – especially common for independent and rural programs like those that ACRES hopes to reach – to evaluate the effectiveness of their efforts.

Second, existing work does not fully explore validity – in its modern conception – in measuring educator noticing. The *Standards* cited in Weyers *et al.* (2023) work outline five sources of validity evidence: a) *test content*, or the degree to which assessment items are appropriate for measuring the intended construct; b) *response process*, or the degree to which assessments tap into the intended cognitive process (e.g. question format); c) *internal structure*, or the extent to which correlations among items align with theoretical expectations (e.g. factor analysis); d) *relation to other variables*, or the degree to which relationships between performance on items and other sources of evidence are as expected (e.g. relationships between tests and criterion); and e) *consequences of testing*, or the degree to which interpretations and the use of data are detailed and lead to positive and desirable outcomes for those affected by the use of the assessment. Thus, the authors' decision to organise their work using Cronbach and Meehl's (1955) structure rather than the *Standards* illustrates an opportunity to take a more granular approach to understand validity, for instance using a framework that more pointedly attends to how respondents interact with the test format (i.e. 'response process') and the outcomes expected from use of the survey (i.e. 'consequences of testing').

Materials and methods

Recognising this need, we present the SAS development and application using guidance from the *Standards for Educational and Psychological Testing* (APA, NCME, and AERA 2014). Using this guidance, we organise our work into three phases: *1: developing the assessment content and response process*, *2: developing the response coding protocol*, and *3: evaluating pre and post changes in SAS responses for a given purpose*. Phases 1 and 2 align with our first research question, and Phase 3 aligns with our second.

Participants and data collection

We asked educators who participated in the complete (i.e. all three sessions) APQ module delivered by ACRES's program coaches (i.e. national rather than regional 'hub' coaches) to respond to identical versions of the SAS twice – once before participating in ACRES and once after. We sent survey invitations to educators as part of their PL welcome emails before the start of the PL (for the *pre* administration) and immediately following the PL (for the *post* administration).

Further, we invited selected educators to participate in 30-minute, six-month delayed-time interviews to assess the durability of learning in APQ. We invited educators according to the criteria of (a) having participated in all three sessions of the module (for consistent dosage); (b) having participated in a cohort with two or more other colleagues (for fidelity of the ACRES model, which is based on peer feedback); and (c) receiving coaching from a coach employed by our non-profit organisation (for access to video recordings of cohort sessions to triangulate with other data collection events and for greater likelihood of program fidelity). Educators were compensated $50 for completing both the *pre* and *post* versions of the survey and $100 for participating in the interview.

All data collection was approved by Salus IRB 21,188–03 for human subjects research. Educators who agreed to participate in the research indicated their agreement before beginning the PL through consent forms emailed to them as part of registration.

Results and discussion

Below, we organise our results by goal. In each section, we describe our approach, data collection, and the results associated with that goal. In some cases, we present our process through an outline format to make it easier to follow our design iterations. We explore the collective meaning we glean from addressing both goals in our Conclusions and Implications section.

Goal 1: developing the SAS structure process and results

This goal concerns how we developed the SAS and includes data and associated analysis from multiple SAS iterations. It addresses our first research question and consists of two phases.

Phase 1: developing the assessment content and response process

Process

We aimed to design a tool to engage educator respondents in noticing the APQ skill in practise in ways that mirrored how they reflected on the use of APQ during the ACRES sessions. In other words, we wanted respondents to first observe a learning environment and attend to specific aspects that stood out to them, then use what they learned from APQ to think about what they noticed, and finally apply what they learned to draw some conclusion from their thinking (van Es and Sherin 2002; see Figure 2). We would consider evidence of the success of our program if respondents, in *post* responses, attended to purposeful questioning more specifically and made observations and recommendations that were closer aligned with the skill objectives of APQ (see Figure 1).

We drew from the structure of ACRES sessions (i.e. feedback sessions where educators notice and share a ‘strength’ and ‘opportunity for growth’) to design SAS questions to elicit data on the skills in which we were interested in assessing growth (i.e. recognising strengths and opportunities in an educator’s use of the focal skill of APQ). To do this, we engaged in design iteration conversations, punctuated by small pilots, with ACRES’s national coaches, positioning them as content experts. We further reiterated the format of the SAS and response process through internal discussion within the research team, which we shared again with coaches and external evaluators with expertise in OST STEM education for further feedback.

Results: Assessment Content. Our sequence of steps in determining the assessment content are outlined below. ‘Reflections’ refer to feedback from four ACRES coaches in conversation with the research team during weekly, one-hour programmatic meetings.

(1) First consideration: We used written vignettes to describe a fictional educator's activity. We selected this option because it was easy to embed in the existing forms that educators completed as participants in AnonP.
   (a) Reflection: This format could not represent the nuances to which we wanted respondents to attend. For instance, skills such as leaving 'think time' for youth to respond after an educator posed a question and engaging with multiple youths without gender or racial discrimination were challenging to articulate in short reading passages and thus would likely not appear in educators' responses.
(2) Second consideration: We considered using videos of actual practise in OST learning contexts to prompt educator reflection, drawing from opportunities in the existing literature to elicit educator reflection from video (Clarke and Hollingsworth 2002) and aligning with the APQ format in which educators exchange feedback on the performance of the STEM facilitation skill based on peers' submitted video evidence (see Figure 2).
   (a) Reflection: The live recordings did not allow respondents to identify the breadth of possible implementations of APQ, particularly in a short clip.
(3) Third consideration: Inspired by animated assessments in other arenas, such as CPR training, we presented educator practise for feedback using an animated version of an OST educator's interactions with youth. After considering alternative software, we adopted Vyond to create the animated videos.
   (a) Reflection: The animated video created using Vyond provided numerous options for characters' (i.e. educators and youth) features (e.g. appearance, voice) and accommodated the budget for developing the SAS. Using the software instead of live video also made it easy to change the script, characters, and setting in response to feedback during our reiteration.

Based on this assessment, we retained the third format. The final SAS is approximately 1.5 min long and features an educator introducing a slime-making activity to youth in her classroom (see Figures 3 and 4).

Results: Response Process. Response process refers to how educators respond to the animated video to provide their reflection. Our consideration of response process options is outlined as follows. The 'Reflections' indicated here are based on the reflections of the research team. Data used to make these reflections are indicated in the text.

(1) First consideration: Ease of interpretation for PL providers was a priority in our development of the SAS, so we considered a multiple-choice response format. Multiple-choice responses can be easily summarised and compared using free survey software (e.g. Google Forms).
   (a) Reflection: This approach yielded a high ceiling effect, with 80% or more respondents providing correct or partially correct responses for each multiple-choice item in the *pre* administration of the survey ($n = 45$). Recognising that this result may indicate an ineffective *program* rather than a poor instrument, we triangulated these scores with our 6-month delayed follow-up interviews in which we asked educators ($n = 14$) to describe, if possible, their current use of the APQ skill. All educators we interviewed described their use of APQ in

Figure 3. Screenshot of the SAS animation. The educator, Mary, is seated on the left, with three youths on the right side of the table.

practise and their awareness of the skill as they reflected on their interactions with youth. These results suggested that participating educators *did* shift their understanding and use of APQ through taking part in the PL but that the multiple-choice format of the SAS was not effective in reflecting this growth. Thus, we considered how the multiple-choice format restricted the diversity of possible observations in an instructional context, especially if we were to provide a manageable number of items.

(2) Second consideration: We considered an open-ended format to align more with participants' experiences in an APQ cohort. This open-ended response format was consistent with existing efforts to measure noticing – recall that it was the preferred format indicated in the reviews discussed earlier (Amador *et al.* 2021, Weyers *et al.* 2023). Thus, this pivot further enabled us to build our validity case both (a) using a response format that is widely adopted in research on educator noticing and (b) using a noticing context (i.e. video) that is popular to elicit demonstrations of noticing skill. During APQ sessions, participants are prompted to suggest a 'strength' exhibited in a video provided by the peer educator in their APQ session. Then, after all peers have commented on a 'strength', they each provide an 'opportunity for growth'. To mirror this format, we revised the response format of the SAS to offer two open-ended questions and asked each survey respondent to provide a 'strength' for the SAS educator as well as an 'opportunity for growth'. We added the instruction 'list as many as you can think of' to indicate our desire to see multiple ideas. This format also aligns with other research on teacher noticing that has used open-ended prompts to comment on 'What did you notice in this video?' and a request to expand on 'is there anything else you noticed?' (Lam and Chan 2020).

Mary (Educator) introduces the activity to the educator watching the video. She is standing in her classroom. No students are there yet.

Mary: I know that my afterschool youth love to make different types of slime at home. For today's activity I want to bring more STEM into the process of making slime. My goal is to have the youth use the science process to investigate how to make the best slime.

[scene change]

Mary sits around a table with 3 youths. There is a green slime substance on the table in the middle. Room is set up with science-y equipment.

Mary: You've all said that you're interested in making different types of slime. So today our goal is to find out how to make the best slime. First, we have to figure out the physical properties of slime. What are some slimy things that you can think of?

(5 second pause)

Youth 1: Snails and frogs.

Youth 2: Jelly and worms.

Youth 3: Old lettuce in my fridge and gummy worms .

Mischa (Youth 3): I think snakes are slimy!

Mary: Mischa, can you say more about why you think snakes are slimy?

Mischa (Youth 3): They're shiny like a lot of slimy things. I've never touched a snake before, but I bet it's gross!

Mary: A lot of slimy things are shiny, but snakes are actually dry. Good thought though! All those other things are definitely slimy. Does anybody else have anything else to share? No? OK let's move on.

Figure 4. Script of the SAS.

(a) Reflection: The open-ended response format was most suited to the response process we wanted to elicit and more capable than forced-choice alternatives of being sensitive to diverse responses and how they may shift over time. Thus, we retained the open-ended response format for the SAS using the educator animation.

Phase 2: developing the response coding protocol

Process. The choice of an open-ended response format required an approach to text analysis rather than simply calculating correctness, such as could be done with multiple-choice items. We analysed the open-ended responses ($n = 133$) using emergent coding coding (Miles *et al.* 2019), which aligned with our purpose to ground the feedback content in what our participating educators expressed in the session (Charmaz 2006). Since surveyed educators provided feedback on SAS educator *actions*, we used gerund coding (Miles *et al.* 2019). During coding, we hid the timing (i.e. *pre* or *post)* to reduce possible desirability bias to suggest more program-aligned feedback in *post* responses.

After developing these gerund codes, we shared a single Google Doc file of the code list, including definitions, with all four national ACRES coaches for feedback. They asynchronously (i.e. individually, at times of their choosing) reviewed the code list and indicated which described actions were intended outcomes for educators completing the APQ module using the 'comments' feature on the Google Doc file. All coaches interacted with the same shared file, allowing them to express agreement and build nuance on one anothers' responses. This shared access to the same file was valuable as each coach had different experiences in leading other ACRES modules (e.g. Facilitating Engineering Pracitses, Make Maths Engaging), so they could build on one another's comments by sharing how actions reflected in the codes may have applied more to other modules and pose questions to one another. We used this feedback to designate codes that the coaches evaluated as direct focal skills in the program (i.e. '*intended*') from those that were associated with the intended goals but not directly taught (i.e. '*accessory*'). Often, 'accessory' codes were ones that coaches had indicated were emphasised more in follow-up modules, such as Make Math Engaging. After developing these interpretations, we shared them with two of the coaches to member-check our articulation of their alignment with APQ objectives – in other words, our determination of actions as 'intended' by the program goals or 'accessory' to the main objectives of APQ.

Results: Internal Structure. We developed our codebook using the paired *pre* and *post* data from 31 educators who participated in 13 unique cohorts and completed the final iteration of the survey. Table 1 describes the demographic distribution of these educators. While we recognise that many demographic identity affiliations can influence educators' experiences and actions, we collected these demographic details of all participants in ACRES to monitor progress towards scaling up our program: a) geographically across the U.S.; b) across rural, urban, and suburban settings; and c) to engage a more racially representative population of educators.

All of the educator data included in our analysis came from educators who participated in cohorts led by our most experienced coaches (i.e. coaches employed by ACRES). This selection enabled our comparison of *pre* and *post* data with confidence in likely change according to defined program objectives. Including educator data from hub coaches with less experience – and who we had encouraged to experiment with program adaptations – may have introduced variables of educator experience and program fidelity. While we feel that these variables are important to study, since our purpose is to understand the utility of the SAS, we chose to examine responses from educators experiencing APQ under similar conditions that are most likely to be program-aligned.

The final codebook was the product of three researchers' independent coding and subsequent meetings to consolidate codes and negotiate their descriptors. We documented 27 final codes in a tabulated codebook that contains code descriptors, notes to clarify similar codes, and examples. We organised these codes into three categories according to the focal point of respondents' noticing – the educator, the classroom, or the youth. This organisation supports Research Question 2 and resonates with the summary in Star and Strickland (2008), which suggests video-based PL supports a shift of noticing away from

Table 1. SAS educator demographics.

Category	Subcategory	# of educators	% of educators
Region	South	10	32.26%
	Midwest	9	29.03%
	West	7	22.58%
	Northeast	5	16.13%
Geographic setting of educators' program	Urban	10	32.26%
	Rural	7	22.58%
	Suburban	5	16.13%
	Rural/Suburban/Urban	4	12.90%
	Suburban/Urban	4	12.90%
	N/A	1	3.23%
Gender identification	Female	29	93.55%
	Male	2	6.45%
	Nonbinary	0	0.00%
Racial identification	White	18	58.06%
	Black Or African American	7	22.58%
	Hispanic, Latino/a/x, Or Spanish Origin	3	9.68%
	Black Or African American & White	1	3.23%
	Asian	1	3.23%
	Asian/Middle Eastern Or North African	1	3.23%
Years of experience in facilitating STEM activities with youth	0-5	18	58.06%
	6-10	5	16.13%
	11-15	2	6.45%
	16+	2	6.45%
Educational Setting	Afterschool Program	20	64.52%
	Child Care Center	5	16.13%
	Youth Camp	2	6.45%
	Library	2	6.45%
	Other	2	6.45%

attention on the educator as an isolated individual to include more attention to youth. We defined *classroom-centric* noticing as participant responses that attended to the context of the classroom and classroom dynamics. We defined *youth-centric* noticing as participant responses that noticed opportunities the animated educator created for youth. We defined *educator-centric* noticing as respondents' observations of the animated educator *without* noting a relationship to youth or the classroom context. For instance, we considered feedback that suggested that the SAS educator could ask more open-ended questions to be *educator-centric* because of the focus on educator behaviour without a consequential youth outcome. We classified feedback that discussed making age-appropriate decisions as *classroom-centric* because it related to knowledge of the classroom body. We considered feedback that noted how the SAS educator prompted a youth to say more about an idea they suggested to be *youth-centric* because it relates to making space for individual youth to express themselves more. Our codes and their categorisations are listed in Table 2.

Current & Ongoing Work: Consequences Of Test Use. We developed the SAS as part of a PL program that is founded on the notion that supportive and brave places are essential for educators to build trust with peers such that feedback can be exchanged to drive professional growth. The feedback that educators offer to their peers in the programme is evidence of what they notice in educator activity, just as the feedback that our educator respondents provide the SAS educator is evidence of what they notice

Table 2. Codes of feedback to SAS educator.

		Strength	Opportunity
Educator-centric			
Accessory outcome	Asking questions naturally	Questions seem to come naturally or effortlessly.	Questions could be improved to come more naturally or effortlessly.
	Connecting to science facts	Connects the learning to science facts that she shares.	Could connect the learning to science facts that she shares.
	Modeling scientific thinking	Uses questions to model scientific habits, such as curiosity and observation.	Could use questions to model scientific habits, such as curiosity and observation.
	Modifying or extending the activity	Changes the activity, either through modifying the existing activity or adding to the activity.	Could change the activity by modifying the existing activity or adding to the activity.
Intended outcome	Asking 'open-ended questions'	Asks open-ended questions.	Could ask open-ended questions.
	Asking a variety of questions	Uses a variety of questions.	Could improve the variety of her questions.
	Breaking down or broadening questions	Expands or narrows the scope of the question being asked.	Could expand or narrow the scope of the question being asked.
	Connecting with the goal or larger scientific habits of mind	Connects her questions to the goal of the activity or to scientific process more generally, such as making observations or generating hypotheses	Connect her questions to the goal of the activity or to scientific process more generally, such as making observations or generating hypotheses
	Considering question phrasing	Effectively words her questions.	Could more effectively word her questions.
	Considering question timing	Uses appropriate timing of her questions.	Could improve the timing of when she asks her questions.
	Framing for youths	Effectively sets up the youths for the activity.	Could more effectively set up the youths for the activity.
	Planning questions	Appears to have planned questions ahead of teaching.	Could have planned questions ahead of teaching.
	Asking specific questions	Asks a specific question that is effective.	Could ask a specific question to be more effective.
Classroom-centric			
Accessory outcome	Connecting to ideas in the 'real world' or outside of class	Makes connections to something outside of class that youths may know about or be interested in. Includes connections to other subjects.	Could make connections to something outside of class that youths may know about or be interested in. Includes connections to other subjects.
	Creating a welcoming learning environment	Makes the learning environment welcoming to youths.	Could make the learning environment welcoming to youths.
	Demonstrating knowledge of learners or learning contexts	Activity shows that she knows youths' strengths and difficulties that are specific to the youths or their contexts.	Activity could do more to show that she knows youths' strengths and difficulties that are specific to the youths or their contexts.
	Encouraging youths' ownership of learning	Creates space for youths to direct their learning. This also includes de'-'centring the teacher as the evaluative authority, e.g. by asking questions rather than evaluating responses.	Could make space for youths to direct their learning. This also includes de'-'centring the teacher as the evaluative authority, e.g. by asking questions rather than evaluating responses.
	Keeping youths engaged	Activity keeps youths on task and interested in the activity.	Activity could do more to keep youths on task and interested in the activity.

(*Continued*)

Table 2. (Continued).

		Strength	Opportunity
Intended outcomes	Getting youths to talk to each other	Activity encourages youths to collaborate with each other.	Activity could do more to encourage youths to collaborate with each other.
	Broadening participation of more youths	Involves multiple youths in the discussion.	Could involve more youths in the discussion.
Youth-centric			
Accessory outcome	Validating youth thinking	Responds to youths' thinking in ways that recognise it as valuable.	Could do more to show that she values the youths' contributions.
	Noticing and responding to youth work or ideas	Sees something that a youth does or needs and takes action because of that noticing.	Could take action on something she notices from a youth.
Intended outcome	Encouraging deeper thinking	Action elicits different kinds of thinking or deeper thinking from youths.	Action could do more to elicit different kinds of thinking or deeper thinking from youths.
	Encouraging youth to talk more about their idea	Prompts a youth to say more about an idea they have already introduced or explain the thinking behind the idea.	Could get a youth to say more about an idea they have already introduced or explain the thinking behind the idea.
	Asking 'follow-up' questions	Asks additional questions to get a youth to say more.	Could ask additional questions to get a youth to say more.
	Providing think time	Gives time after asking a question for a youth to think and provide a response.	Could give time after asking a question for a youth to think and provide a response.
	Listening to youth	Demonstrates listening to a youth, such as by revoicing.	Could demonstrate listening to youth, such as by revoicing.
Comments on video quality	Includes some reference to the quality of the video, e.g. the video was hard to hear or the voice was robotic.		
No ideas for feedback	Not having an idea for feedback or articulating difficulty in generating ideas		

in the animated educator's activity. In this way, we designed the SAS to assess how educators' attentiveness to specific details evolves – particularly how they attend to educators as isolated individuals or learners in community with youth – during their participation in the APQ module. We have *not* validated it as an interpretation of educators' use of APQ in practise. Instead, the SAS may be used by PL providers as a tool for reflecting on their delivery of PL content (i.e. 'are my educators noticing what I want them to notice?').

Future work with this codebook involves piloting its use with coaches themselves to clarify codes and their applications, which will then be converted to a short, 2-page reference to guide the use and interpretation of the SAS within OST networks or organisations without the support of ACRES. We feel that this is important to produce for: (a) the SAS to be accessible to the populations that can most readily make use of it (i.e. PL providers in OST education) and (b) to explicitly articulate the interpretations the SAS was designed to make – for feedback and reflection rather than high-stakes performance evaluations. This activity will occur with the coaches who provided feedback on aligning codes with ACRES objectives.

Goal 2 results: evaluating SAS responses process and results

We evaluated the SAS responses to explore our second research question of how participating educators' noticing of the SAS educator differentiated between *pre* and *post* completion of the SAS. We specifically evaluated these changes across educator-, classroom, and youth-centric noticing categories.

Phase 3: evaluating responses

Process. We tabulated *pre* and *post* responses for each category on different sheets within a spreadsheet file (see Figure 5, illustrating the organisation of this data). For each coded response, we indicated whether the response was provided in the 'strengths' or 'opportunities' field and if the coded excerpt provided feedback that was 'intended' or 'accessory'. Then, we reviewed each sheet of responses to summarise the characteristics of the feedback in terms of specificity, diversity of ideas, relative proportion of feedback related to strengths compared to opportunities, and relative proportion of feedback related to intended compared to accessory outcomes.

Results: Alignment With Expected Associations. We expected that codes that we categorised as 'accessory' – i.e. those that are related to but not directly taught in APQ – would decline between *pre* and *post* administration of the SAS, as educator respondents introduced feedback to the SAS educator that was more reflective of the feedback they exchanged with one another during the APQ sessions. Since the skill of APQ is founded on principles of student-led learning, we also expected that *post* responses would shift away from educator-centred feedback towards feedback that is student-centred.

Indeed, we noted that outcomes considered by our coaches to be accessory to the main objectives of the APQ course declined between *pre* and *post* administration, particularly in educator-centric feedback. Declines in accessory feedback on youth outcomes existed to a smaller degree. We noted increases in intended feedback only for youth-centric outcomes (see Table 3).

We further considered how specific noticing codes (see Table 2) compared *pre* and *post* to assess where shifts were most apparent within educator-, youth- and classroom-centric observations.

Media Title	Cohort	Excerpt Copy	Feedback	Accessory	Intended
Participant: 17	AC127PQ	providing feedback and asking the student that said snake to expand on that,	Opportunity	TRUE	TRUE
Participant: 17	AC127PQ	saying good try but snakes may seem slimy but they are dry.	Opportunity	TRUE	FALSE
Participant: 10	AC282PQ	- correcting student in a nice way	Strength	TRUE	FALSE
Participant: 10	AC282PQ	more time for discussion; provide example and let students think of more (with time to think)	Opportunity	FALSE	TRUE
Participant: 6	AC241PQ	Only asked follow-up for "wrong" answer. Why do we think the other things are slimy?	Opportunity	FALSE	TRUE
Participant: 6	AC241PQ	Only asked follow-up for "wrong" answer. Why do we think the other things are slimy?	Opportunity	FALSE	TRUE
		gave the students the opportunity to think for themselves and then			

Figure 5. Excerpt of the spreadsheet used to analyse codes by noticing category and SAS timing. Note that each participant may have multiple codes as individual participants expressed more than one unique idea.

Table 3. Comparison of coded feedback between pre and post administration of the SAS.

		Pre	Post	Percent of codes in post
Educator-centred	Accessory	20	9	31.0%
	Intended	37	37	50.0%
Total		57	46	44.7%
Classroom-centred	Accessory	31	26	45.6%
	Intended	16	13	44.8%
Total		47	39	45.3%
Youth-centred	Accessory	15	13	46.4%
	Intended	26	37	58.7
Total		41	50	54.9%

- Within youth-centric noticing, we observed that feedback reflecting on the SAS educators' practise of 'encouraging youth to talk more about their ideas' markedly increased, with nearly two-thirds of these 33 codes appearing in *post* responses. This shift is consistent with how coaches are introduced to the purpose of APQ in their coaching module (see Figure 1) as helping 'youth expand and clarify their thinking, develop their reasoning, and navigate science and engineering experiences'.
- 'Connecting to science facts' particularly *decreased* among educator-centred outcomes, with roughly three-quarters of these 27 codes being applied in *pre* responses.
- Educator-centred feedback of 'asking open-ended questions' and 'asking specific questions' increased, with roughly three-quarters of each of these codes appearing in *post* response coding (14 of 19 codes in "asking open-ended questions and 12 of 15 codes in 'asking specific questions'). Since coaches provided ACRES educators with resources such as a list of purposeful question prompts, this finding is consistent with what would be expected for educators using the APQ resources.
- Our application of codes within the classroom-centred codes was relatively stable.

These findings are also consistent with APQ learning goals (see Figure 1) and APQ coaching strategies such as providing educators with a list of possible purposeful open-ended questions that they can use as prompts in their learning environments.

While comparing code counts supports our validity argument for the SAS by illustrating consistency between SAS analysis and expected outcomes based on course design and objectives, we did not design the SAS to evaluate educator change through code counts alone. By adopting the open-ended response format, we anticipate that qualitative comparison of educators' responses within the three noticing categories can aid PL providers in assessing their communication of the APQ skill among small groups of educators in a PL module. Indeed, we found that qualitative comparison of each noticing category indicated differences between *pre* and *post* observations that showed educator change aligned with APQ objectives.

Our analysis indicated that respondents' *educator-centered* noticing shifted from feedback that reflected a need for educator ownership of the learning experience (in *pre* responses) to feedback that suggested a need for educator activity to build from youth contributions (in *post*) responses. *Pre* responses commented on the SAS educator's role in explaining content to her young learners as opportunities, such as 'She could have introduced/discussed the features of slime'. Responses largely commented on the SAS educator's activity in making connections to the learning goal as a strength. By contrast, the *post* responses reflected more awareness of the SAS educator's role in engaging youth in the process of generating science content, such as 'she [the SAS educator] did really well with the back and forth of learning from them [her youth learners] but also filling in some blanks with her knowledge'. The *post* responses still showed that respondents noticed the SAS educator's action in connecting the learning activity to the goal, but they more explicitly spoke about the relationship between her actions and the youths' contributions. One respondent's observation that the 'teacher's response to the "snake" response wasn't very helpful. She didn't bring it back to the lesson at all' uses the youth's response as an indicator to build feedback on the SAS educator's connection to the goal. Another commented, 'she clearly explained the objective and had the kids think for themselves', tying the SAS educator's role in introducing the activity with a clear distinction of the youth's ownership in generating explanations.

Consistent with the results in Table 3, *classroom-centric noticing* in the SAS was largely static between *pre* and *post* responses. *Pre* feedback often attended to the SAS educators' tone and connections to youth knowledge from outside the learning context (accessory outcomes) and having more youth participate in the discussion, mainly by answering the question (intended outcome). *Post* feedback differed slightly, with more mention of youth engagement with one another, such as suggesting that the SAS educator 'could ask kids to respond to each others' answer to the question or ask their peers a question'.

In addition to being more represented in *post* responses, *youth-centric noticing* evidenced more depth in reflection than in *pre* feedback. Both sets of responses attended to the accessory outcome of the SAS educator's 'correcting' of youth, but *post* responses further explored how the SAS educator could respond after the correction. For instance, one respondent suggested

> Instead of simple correction, the teacher could ask more questions that would let the kid find the correct answer on their own. For example, "I wonder if an object could be shiny yet still dry. Are all shiny things slimy? Are mirrors slimy? Are paper clips slimy?" After receiving the answers the teacher could ask the youth to make conclusions, "So what is common among those things that you listed? Is that what makes an item slimy?"

In contrast, *pre* responses were more evaluative of student responses, such as noting the SAS educator's strength in 'correcting the student but also giving praise to her effort'. While both *pre* and *post* responses commented on the SAS educator's practise of encouraging youth to expand their thoughts, *post* responses provided more specific suggestions. For instance, one *pre* strength was that the SAS educator 'asked them to expand their thoughts', compared to *post* responses that 'when you asked Mischa [one of the students in the video] "can you say more?" it was a strong example of an open-ended question for her to clarify her thinking'. Both *pre* and *post* responses commented on the SAS educator's use of 'wait time' or 'think time' in similar ways; this stasis may be partially attributable to the obvious quick transition of the educator in the video or of shared prior knowledge of SAS educators taking the APQ module.

Contributions & implications

Educators' awareness of strategies that engage youth in OST spaces is paramount in their pedagogical content knowledge (Busch *et al*. 2023). This significance is especially noteworthy when considering the unique capacity of OST programs to provide youth with opportunities for practising science and engineering in ways that engage skills and mindsets beyond what is supported in the formal curriculum (Simpson *et al*. 2020). Thus, PL that supports OST educators in adopting strategies that centre youth ownership of learning, such as in the APQ module, equip educators with critical tools that elevate the STEM learning experiences of program youth. However, analysing the impact of educator change from PL participation can be difficult, especially in regularly-convening OST programs (e.g. afterschool programs) where learning routines are highly variable and youth attendance is inconsistent. Further, for virtual PL like APQ, documenting educator change through observation of practise is logistically difficult, as coaches interact with a group of educators who may represent programs scattered throughout a region – this may be true for PL for formal (i.e. in-school) educators as well as educators working in OST. Thus, we developed the SAS as a tool that can assist PL providers in identifying and making sense of the progress they see in their educators.

In practise, we found the SAS to be an effective tool for assessing educators' noticing of a target skill in practise. In our case, the SAS allowed us to evaluate in what ways ACRES educators noticed the use of APQ and align that noticing with our program goals. The scripted animation format supported our need for video/visual capabilities that allowed respondents to comment on interaction timing and context while also being somewhat flexible to make adjustments to the video following feedback from respondents or advisors. While closed-ended formats restricted our participants' noticing, the open-ended response format allowed respondents to comment on the diversity of micro-interactions and contextual specificities of a learning experience. We suggest that the scripted animation delivery with an open-ended response format may be readily employed for purposes of realising *pre* and *post* changes that may be attributed to a PL experience, especially in instances where the PL focuses on complex, inter-relational skills that are not easily conveyed in writing and/or forced choice response processes. Our in-progress work involves developing a SAS for other modules in our PL menu.

Our coding and analysis exemplify a specific instance of how a tool like the SAS can assess educators' awareness of a specific facilitation skill (e.g. APQ) and compare their understanding of it before and after participating in PL. We specifically indicated its use for educators' shift in attention to youth ownership of learning, a desired area of growth in OST education reform efforts in the U.S (Afterschool Alliance 2015), as well as in-school science education (National Academies of Sciences, Engineering, and Medicine 2024). As our analysis demonstrates, SAS responses may be used in several ways. *One*, comparing the responses within codes associated with noticing categories from *pre* and *post* can indicate how educator respondents' recognition of the target skill in practise may or may not have changed between the beginning and end of the PL program. This application could support individual coaches to reflect on their desired outcomes of a cohort, particularly for a PL program that meets over multiple sessions, like with ACRES. A major driving motivation of ACRES is the realisation that feedback on their professional activity is difficult to acquire, especially for smaller programs that can leave educators professionally isolated; this may be true in small OST program or in schools in more remote regions (Goldhaber *et al.* 2020). We hope that the SAS can give coaches in such contexts a tool for self-reflection. *Second*, we recognise that a code count of *pre* and *post* responses can illustrate where a preponderance of growth has taken place (or not). For instance, regression analyses that include educator experience, PL dosage, and other relevant factors could be associated with numbers of codes that are youth-centric. Or, group means comparisons such as MANCOVA could compare educators' *pre* and *post* responses among the three categories. However, this use of the SAS is *not* validated through the present analysis. We used code count as a way to support the validity of the SAS by illustrating a shift in responses that aligned with APQ's intended objectives, and we did not look at code count applications for other purposes.

While the SAS and its codebook are useful for researchers for evaluating a PL, our goal is to reduce friction against its use by program leaders who generally have not received the funding to carry out programmatic evaluations that require qualitative methods training or software. This need motivates our development of an implementation and use guide that will support coaches in OST education in using a tool such as the SAS to assess their PL program's influence on the recognition of focal skills. This work is ongoing as part of a larger guidebook that we are developing for ACRES coaches.

Acknowledgments

The authors are grateful for the contributions to this work from APQ coaches Becky Tapley, Emma Carey, Perrin Chick, and Hannah Lakin who assisted with code organisation and provided member checking. We also appreciate the foundational work from Sue Allen who led the original design of the SAS.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The research described in this manuscript is supported by the investment from the National Science Foundation AISL program, [2115229].

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