Practitioner-reported Needs for Enacting, Implementing, and Adopting OpenSciEd Curriculum Materials

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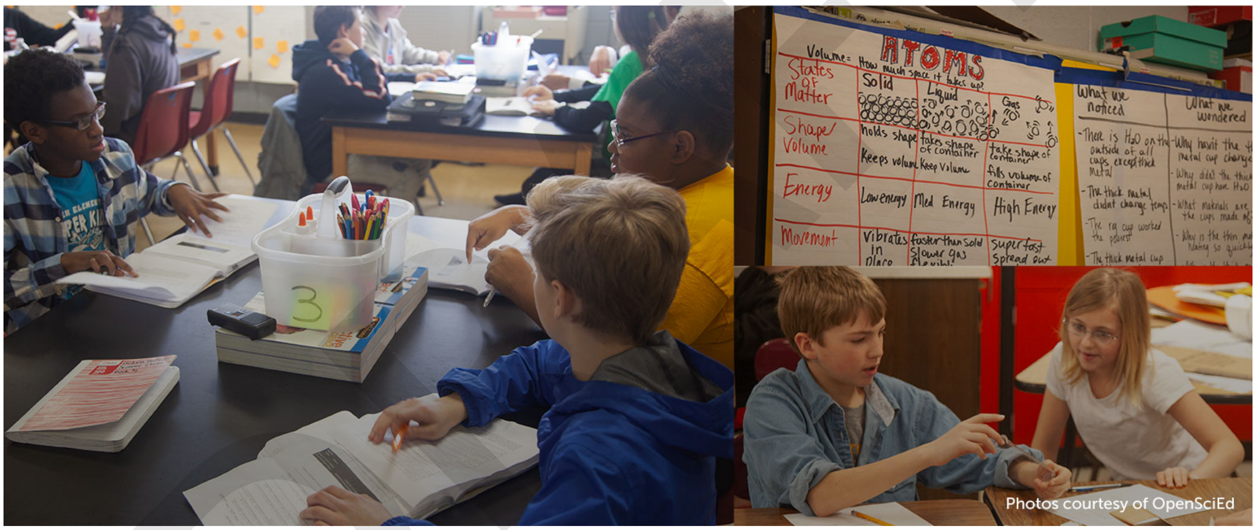

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Executive Summary

We set out to answer four main questions: (1) What do OpenSciEd practitioners describe as their most urgent needs? (2) What factors drive these needs? (3) What are promising solutions for OpenSciEd practitioners? (4) What are priority research questions around OpenSciEd adoption, implementation, and enactment?

We developed and administered a survey that identified 22 challenges from existing OpenSciEd research and asked respondents to rate how often they experienced or observed each one, to describe student groups experiencing equity challenges, and to choose and elaborate on three high priority challenges. We gathered survey responses from 155 teachers and leaders across 34 U.S. states. We also conducted 10 focus group interviews with 28 of the survey respondents. In the interviews we asked participants to describe OpenSciEd challenges, identify their causes, and discuss potential solutions.

Our analysis indicated three broad challenge areas: achieving deep, sustained district adoption and implementation; achieving high-quality, equitable classroom enactment and student engagement; and obtaining evidence of Next Generation Science Standards (NGSS)-based student outcomes. We generated maps that illustrate high priority needs described by OpenSciEd practitioners and how they support addressing each of these challenges. These maps identified seven themes related to supporting OpenSciEd practitioners through research, development, and innovation: (1) access to and benefits of professional learning (PL), (2) supporting teacher agency, collaboration, and management, (3) improving teacher capacity to enact OpenSciEd, (4) meeting students' needs, (5) shifting classroom culture, (6) enabling formative assessment practices, and (7) access to assessment resources.

In particular, PL and other supports for teachers appear to address root causes of many challenges experienced by practitioners. This finding points to the need to increase research and development investments in supporting teachers. These supports could include: PL opportunities on curricular enactment and classroom-based assessment practices, structures for coaching and collaboration, resources and tools that are easily accessible (especially those meeting the needs of multilingual learners and students with disabilities), and district adoption and implementation practices that leverage teachers' assets and promote teacher agency.

More generally, we see a need for research that would elaborate how adoption and implementation of OpenSciEd could drive system-level change in science education. Interviews revealed how OpenSciEd creates pressure for broader changes in school districts' science programs, while also revealing gaps in knowledge about how to connect district curriculum adoption, implementation, and enactment to systems change. We call for research that investigates specific challenges while also addressing needs for change at the system level.

Goals

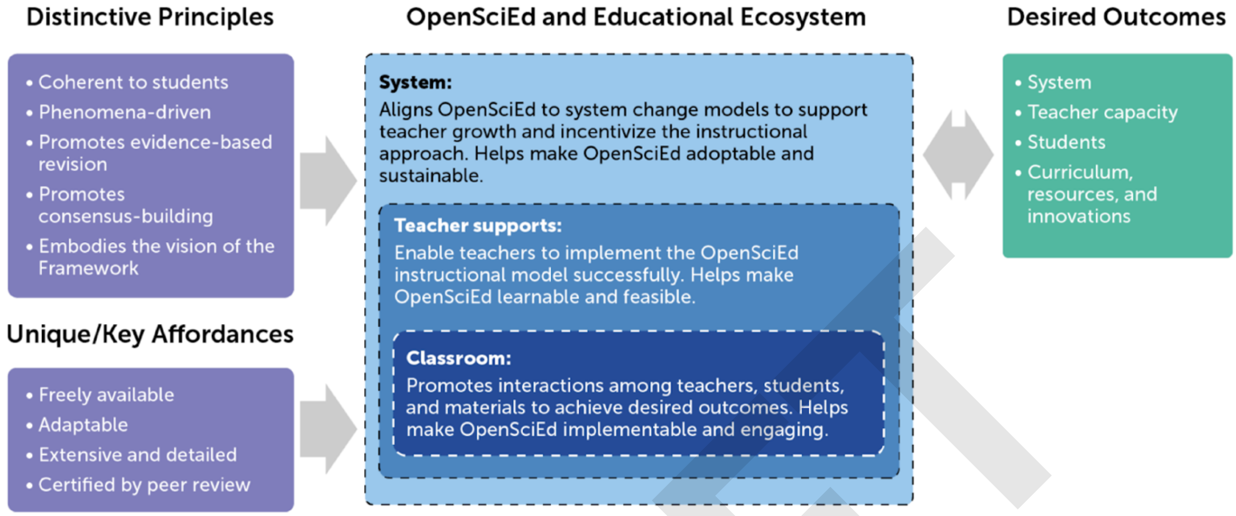
OpenSciEd curriculum materials and professional development (PD) resources are Creative Commons licensed, freely available, and aligned with the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013). The primary goal of this report is to provide direction to researchers, practitioners, policymakers, and developers by motivating research questions, suggesting areas for innovation and development, and identifying avenues for productive systems change. In this report, we aim to address four specific questions based on insights from OpenSciEd practitioners: (1) What do OpenSciEd practitioners describe as their most urgent needs? (2) What factors drive these needs? (3) What are promising approaches for addressing these needs? (4) How can these approaches inform OpenSciEd-enabled research?

Background

OpenSciEd's distinctive affordances (Edelson et al., 2021; Reiser et al., 2021) and high level of anticipated adoption nationwide enable science education researchers to address important knowledge gaps about science learning, teaching, and implementation. OpenSciEd also presents opportunities for resource development and innovation to support implementation and enactment. This study builds on our previous three reports that aim to support the broadening of OpenSciEd-enabled research and innovation. The OpenSciEd logic model (McElhaney, Baker, Chillmon et al., 2022, reproduced in Figure 1), outlines OpenSciEd's distinctive principles, key affordances, system components, and desired outcomes in ways that can inform hypotheses to be tested in potential research studies and highlight knowledge gaps in science education. The OpenSciEd Research Agenda (McElhaney, Baker, Kasad, et al., 2022) engaged a community of OpenSciEd interest holders to collectively articulate research questions and priorities that leverage OpenSciEd distinctiveness, address gaps, and promote equity. The OpenSciEd Research Synthesis (McElhaney, Mills, et al., 2023) reviewed papers on OpenSciEd design, enactment, and teacher PL in order to characterize the progress of current research and identify future research opportunities in these areas.

In this work, we center the perspectives of practitioners, such as teachers and education leaders at the school, district, and state levels. Since the release of our previous reports, districts have had more time to adopt and implement the materials. Following the field tests of the middle school units, more teachers and districts have chosen to pilot test and fully adopt the middle school materials. Moreover, field tests of the high school units have since been conducted. This growth offered us an opportunity to gather more detailed information from practitioners about adoption, implementation, and enactment and determine the most pressing areas of support needed. Our approach is informed by research on how teachers' organizational contexts can constrain or impose barriers to reform (Allen & Heredia, 2021). These factors could include limited opportunities for teachers to plan and reflect with colleagues, an emphasis of school or district administration on test scores, or lack of access to resources. A body of research addressing ways to overcome these barriers focuses on promoting coherence within those organizational contexts to enable reform (Cobb et al., 2018; Newmann et al., 2001). Recent studies focusing on coherence specifically in science education examine the extent to which science education practices and policies are aligned with practice-based science as described in the Framework (e.g., Cherbow et al., 2020).

Figure 1
An initial logic model to guide OpenSciEd-enabled research (reproduced from McElhaney, Baker, Chillmon et al., 2022).



Methods

This report leverages two primary data sources: a survey of 155 participants and focus group interviews with 28 of the survey respondents. In this section, we first describe the survey design, participants, and analysis, then follow with the corresponding details of the focus group interviews.

Survey Design

Based on existing OpenSciEd research from our prior synthesis (McElhaney, Mills, et al., 2023), we identified 22 challenges in four categories (classroom enactment, equity, teacher supports, systemic) (Table 1). Respondents rated how often they experienced or observed each challenge on a scale of 1 (never) to 10 (very often), described student groups who experienced equity challenges in an open-ended response, and selected three challenges they viewed as high priority. Respondents were invited to describe challenges not on our list (though most were elaborations of the challenges we identified). Respondents were also asked to describe the reasons for choosing each high priority challenge. The survey also gathered background formation on the respondents (e.g., grade band, professional experience, role) and their instructional setting (e.g. urban, suburban, or rural). An initial version of the survey was reviewed by two science education experts and administered to a small number of teachers, then revised for clarity and brevity based on the responses and feedback.

Table 1
List of challenges identified for the survey

Classroom enactment challenges	(1) Sustaining student engagement (2) Promoting student agency / autonomy (3) Promoting a classroom culture of "figuring out" (4) Facilitating classroom discussions (5) Promoting 3-D science proficiency (6) Accessing resources (7) Assessing student progress and giving appropriate feedback
Equity Challenges	(8) Promoting equitable classroom participation (9) Sustaining student engagement equitably across student groups (10) Accessing / creating materials adapted to meet the needs of specific student groups (11) Accessing / creating materials adapted to address community issues (12) Promoting consistent enactment of materials across teachers / schools
Teacher support challenges	(13) Using the teacher supporting materials (14) Providing / gaining access to enough PD (15) Providing / gaining access to high quality PD (16) Providing or gaining access to adequate time for planning / reflection (17) Providing or gaining access to professional learning communities, networks, or mentors
Systemic challenges	(18) Improving teacher capacity to teach OpenSciEd (19) Achieving school- / district-wide OpenSciEd adoption (20) Customizing OpenSciEd materials to district / state priorities (21) Implementing assessment systems (22) Shifting funding structures from curriculum to PD

Survey Administration

We made the final survey available online to several national networks of science practitioners. We determined respondents' eligibility based on a pre-screening survey, then randomly selected respondents among eligible candidates in a way that balanced them by grade level and experience level. One hundred and fifty respondents were given a $50 gift card for their time. Other eligible candidates whom we could not provide with a gift card were also invited to respond to the survey without compensation.

Survey Participants

We analyzed responses from 155 participants. Of the respondents, 113 identified as classroom teachers and 42 as education leaders (e.g., instructional coaches, teachers on special assignment, principals, district leaders, county or state officers). Thirty-seven were from urban, 65 from suburban, and 42 from rural settings, with 11 respondents indicating multiple settings. Respondents represented 34 U.S. states, with 94 from NGSS-based states, 54 from states having standards aligned with the Framework for K-12 Science Education (National Research Council, 2012), and seven from states not aligned with the Framework. Among the 113 self-identified classroom teachers, 72 taught only middle school, 28 taught only high school, 11 taught both middle and high school, and two taught upper elementary school.

Survey Analysis

We developed the following emergent categories for student groups experiencing equity challenges: racial groups, multilingual learners (MLLs), students with disabilities or special needs, students who experience poverty, students who read below grade level, students with limited personal experience with the unit phenomenon, students who are chronically absent, and other. We also recoded any respondents' additional write-in challenges that overlapped with one of our 22 challenges. We computed averages of respondents' oftenness ratings and overall percentages of respondents' priority challenges and student groups experiencing equity challenges. We summarized responses for all respondents as a single group and separately for middle and high school teachers, teacher and education leaders, and respondents from urban, suburban, and rural settings.

Focus Group Participants

Of the 155 respondents to the survey, we selected a random sample, balancing representation across location (state and urban/suburban/rural) and grade level (middle versus high school) to invite to the interviews, excluding those who had limited OpenSciEd experience or who did not give complete survey responses. Final assignments for teacher and leader focus groups were based on availability and role (teacher versus leader), with the secondary goal to create heterogeneous groups across different dimensions (location, grade brand, teaching experience) within teacher and leader sessions.

Focus Group Procedure

We interviewed a total of 28 practitioners (10 leaders and 18 teachers) in 10 focus group sessions (four leader and six teacher sessions) with two to four participants in each session. Each focus group was assigned two of the six topics identified from the survey analysis (described below) based on a combination of which challenges the session participants selected in their survey and a balance of topics across the different sessions (with every theme discussed in two to three sessions).

Focus group participants were asked to complete a short questionnaire in advance to introduce their assigned topics and to gather additional context about how each participant experienced their assigned topics. Each 60-minute focus group session started with a warm up introduction about their overall OpenSciEd experience. Then for each theme, participants were asked to describe how they experience the challenges around the theme, identify possible causes for those challenges, and finally to discuss solutions, including both solutions they had tried or ones they imagined might be implemented. All focus group participants were paid $150 for their time.

Focus Group Analysis

We transcribed all the interviews and coded the transcripts for how practitioners described and connected main topics identified in the survey analysis. Practitioners described challenges in ways that constitute obstacles to one of the three following broad outcomes: (1) Deep, sustained district adoption and implementation, (2) High-quality, equitable classroom enactment and student engagement, and (3) Evidence of NGSS-based student outcomes.

We then created maps that illustrate relationships and dependencies among needs that practitioners identified in the focus group interviews (Figures 2–4, below). These maps are inspired by maps of enabling conditions for project-based learning (Potvin et al., 2022). The arrows between practitioner needs represent ways that meeting one need can enable the meeting of another, ultimately facilitating progress toward the desired broad outcome. Note that the maps reflect only what practitioners articulated in the focus group interviews. We did not include needs or connections based solely on existing research literature.

Survey Findings

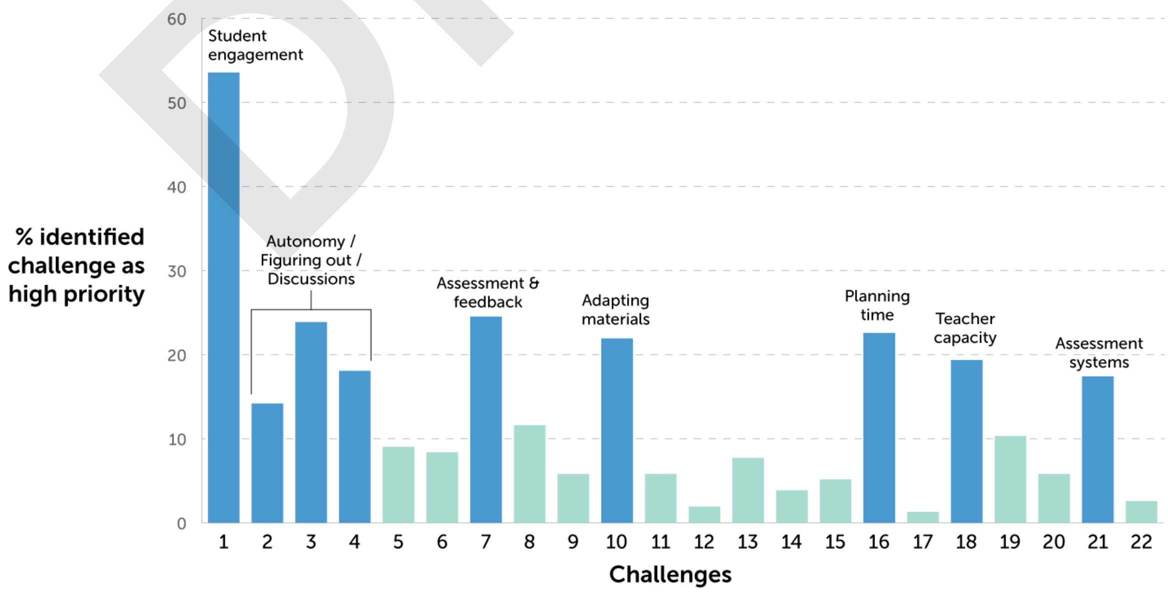
We organize this section based on three findings emerging from the survey analysis related to high priority practitioner needs, equity challenges for student groups, and key differences between practitioner subgroups.

Finding 1: We grouped practitioners' highest priority needs into six general areas: student engagement, classroom culture, assessment, materials adaptation, teacher planning and reflection time, and teacher capacity.

Figure 1 shows the percent of respondents who identified each of the 22 challenges as a high priority. All these challenges identified as highest priority except for one (adapting materials) were also among the seven challenges respondents reported as experiencing or observing most often. Based on the survey analysis, we identified the following six high priority areas of support for practitioners.

Figure 2

Percent of respondents who identified each challenge as one of the three highest priority challenges.



Sustaining student engagement. Practitioners noted that the amount of time required for students to "figure out" (e.g., investigate, model, revise, and explain) can contribute to declining interest over time. Students can view the process of iterative revision to be repetitive rather than an opportunity for growth. Additionally, some students struggle to sustain participation in discussion activities, especially multilingual learners (MLs) and students with disabilities (see Finding 2, below).

Shifting classroom culture. Practitioners observed that many students must make substantial adjustments from a traditional science culture to a phenomenon-based culture. The adjustment entails transitioning from learning facts, producing correct answers, and being told what to do next to figuring out phenomena, sharing work-in-progress, and determining for themselves what to do next. This finding points to the need to further support teachers' and districts' efforts to shift classroom interactions in ways that align with OpenSciEd's pedagogical model.

Implementing coherent assessment approaches. Practitioners report having to transition from typical assessment approaches to new approaches that are coherent with the OpenSciEd instructional model. Aspects of assessment requiring support include the difficulty and complexity of three-dimensional assessment tasks for students, enacting formative assessment practices (such as monitoring student progress and giving timely and helpful feedback), and aligning OpenSciEd activities and work products to grading expectations. These challenges are consistent with broad challenges related to assessing NGSS-based science performance (e.g., Pellegrino, 2013).

Materials adaptation and meeting the needs of specific student groups. Practitioners expressed the need to adapt OpenSciEd student-facing materials (such as handouts, assessments, and instructional slides) to meet the needs of specific student groups. In particular, adaptations that provide additional support for reading and writing were most commonly named. Practitioners also mentioned the need to support students' process of figuring out with additional scaffolds for students' engagement in science practices (especially students with disabilities and individual education plans).

Enabling access to planning and reflection time. Practitioners described aspects of OpenSciEd pedagogy that require additional planning and reflection time, relative to typical materials. These aspects include comprehending, preparing, and planning lessons (especially the first time a unit is enacted); monitoring student progress and giving students feedback; participating in PL; and collaborating with colleagues.

Increasing teacher capacity to enact OpenSciEd. Building and district leaders in particular emphasized the profound shifts in pedagogy that teachers must make when transitioning from typical materials to OpenSciEd, as well as the amount of experience, PL, and administrative support teachers need in order to make these shifts. Both teachers and leaders noted that unilateral OpenSciEd adoption on the part of district administration can inhibit buy-in from teachers.

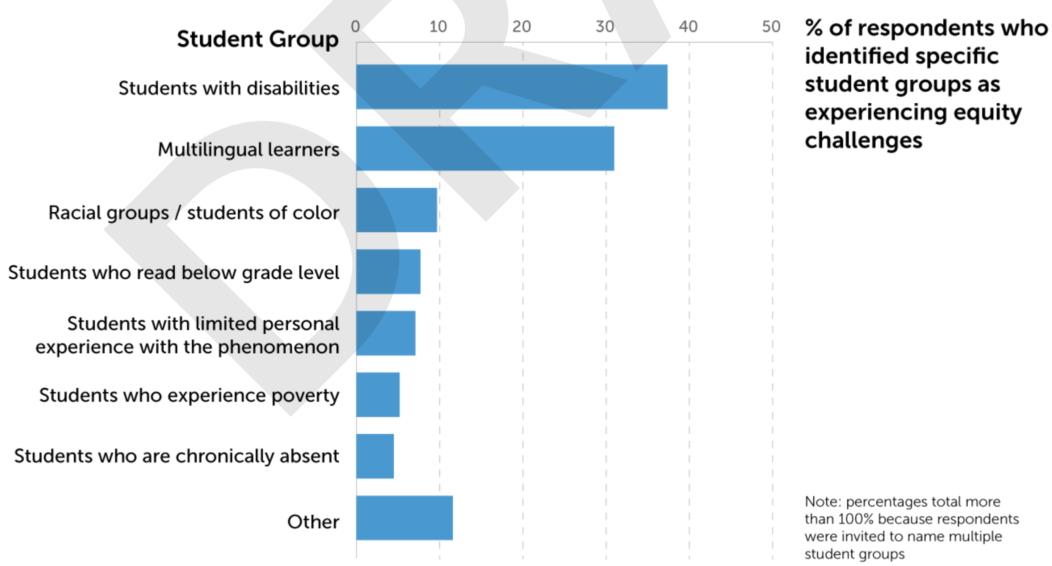
Finding 2: Practitioners identified two student groups who need the most support with OpenSciEd: (1) students with disabilities and (2) multilingual learners.

Table 2 lists the percent of respondents who identified specific student groups as experiencing equity challenges. Students with disabilities (37.4%) and MLs (31.0%) were named with the greatest frequency compared to other student groups. This finding also echoes several of the high priority needs from Finding 1 that are amplified for these student groups, especially sustaining student engagement and adapting materials.

This finding is consistent with identified needs for targeted supports for MLs (Lee et al., 2021) and students with disabilities (McGrath & Hughes, 2018) for engaging in practice-based science instruction. Both MLs and students with disabilities may require additional supports for engagement in science and engineering practices that require extensive linguistic (reading, writing, talking) or physical tasks (laboratory activities, engineering designs). The findings are also highly consistent with data from the OpenSciEd middle school field test (Edelson et al., 2021) reporting that 84% of teachers said materials were accessible to struggling readers, 76% said materials were accessible to students with IEPs, and 68% said materials were accessible to MLs. These percentages are in general agreement with the percentages of our respondents identifying these student groups as experiencing equity challenges. Our findings may indicate slightly higher levels of needed support because teachers who were not part of the field test may have been less well-supported in their OpenSciEd implementation.

Figure 3

Percent of respondents who identified specific student groups as experiencing equity challenges.



All other student groups were named by less than 10% of respondents, likely reflecting OpenSciEd's intentional design efforts to anchor units to phenomena that were relevant to diverse student audiences (Penuel et al., 2022). This result is also consistent with empirical research findings showing students from all racial backgrounds report OpenSciEd instruction to be relevant and that they contribute to classroom discussions (Edelson et al., 2021).

Finding 3: Practitioner subgroups (teachers and leaders; middle and high school teachers; urban, suburban, and rural settings) were generally aligned in their perceptions of priority areas for OpenSciEd support, with a few key differences.

Teachers versus leaders. Teachers' and education leaders' responses generally exhibited high agreement, though there were two main exceptions. (1) Teachers identified *sustaining student engagement* as a priority challenge with higher frequency (59%) than leaders did (38%). (2) Leaders identified *accessing or creating materials adapted to meet the needs of specific student groups* as a priority challenge with higher frequency (33%) than teachers did (18%). These differences are aligned with the nature of teachers' daily attention to students in the classroom and leaders' broader attention to the needs of students across classrooms or schools. In addition, leaders identified *improving teacher capacity to teach OpenSciEd* as a priority challenge with higher frequency (33%) than teachers did (14%). This difference likely reflects the leaders' focus on district level implementation, adoption, and capacity building, relative to teachers. Overall, differences in responses between leaders and teachers emphasize the need for researchers to seek perspectives from education practitioners at multiple organizational levels.

Middle versus high school teachers. Teachers who teach only high school rated challenges with *sustaining student engagement* as occurring more often (7.5 out of 10) than teachers who teach only middle school (5.9 out of 10), and a greater percentage of these high school teachers identified engagement as a priority challenge (75%) than the middle school teachers (53%). We observed a similar pattern with the challenge of *promoting a classroom culture of "figuring out."* Because the OpenSciEd high school units are currently being field tested, our high school teacher respondents were primarily field test participants and are therefore newer to OpenSciEd than many middle school teachers. This difference may partly explain the gap we observed in survey responses. However, the gap is also consistent with the pedagogical shift to storyline units being greater for high school science teachers (who tend to use more direct instructional approaches) than middle school teachers. Research should re-examine this gap after the high school units are officially released and high schools have had more time to adopt and implement OpenSciEd.

Urban versus suburban vs. rural settings. Averaging across all 22 challenges, respondents from urban schools rated OpenSciEd-related challenges as occurring more often (5.5 out of 10) than respondents from suburban (4.8 out of 10) and rural schools (4.7 out of 10). In particular, respondents from urban settings rated challenges related to *promoting agency and autonomy* (6.0 out of 10), *promoting a classroom culture of "figuring out"* (6.2 out of 10), and *promoting equitable participation* (6.1 out of 10) as occurring more often than respondents from suburban and rural settings. These gaps are consistent with research that identifies barriers to practice-based science pedagogy in urban settings (e.g., Songer, 2002) such as limited time and resources, large class sizes, high student and teacher turnover, and limited instructional freedom.

Focus Group Interview Findings

We organize these findings based on the three broad outcomes identified in the analysis of the focus group interviews: (1) Deep, sustained district adoption and implementation, (2) High-quality, equitable classroom enactment and student engagement, and (3) Evidence of NGSS-based student outcomes. For each outcome, we present and discuss the OpenSciEd practitioner needs map that is related to that outcome, then we include two vignettes that illustrate practitioners' firsthand experience (as described in a focus group interview) with an emergent theme.

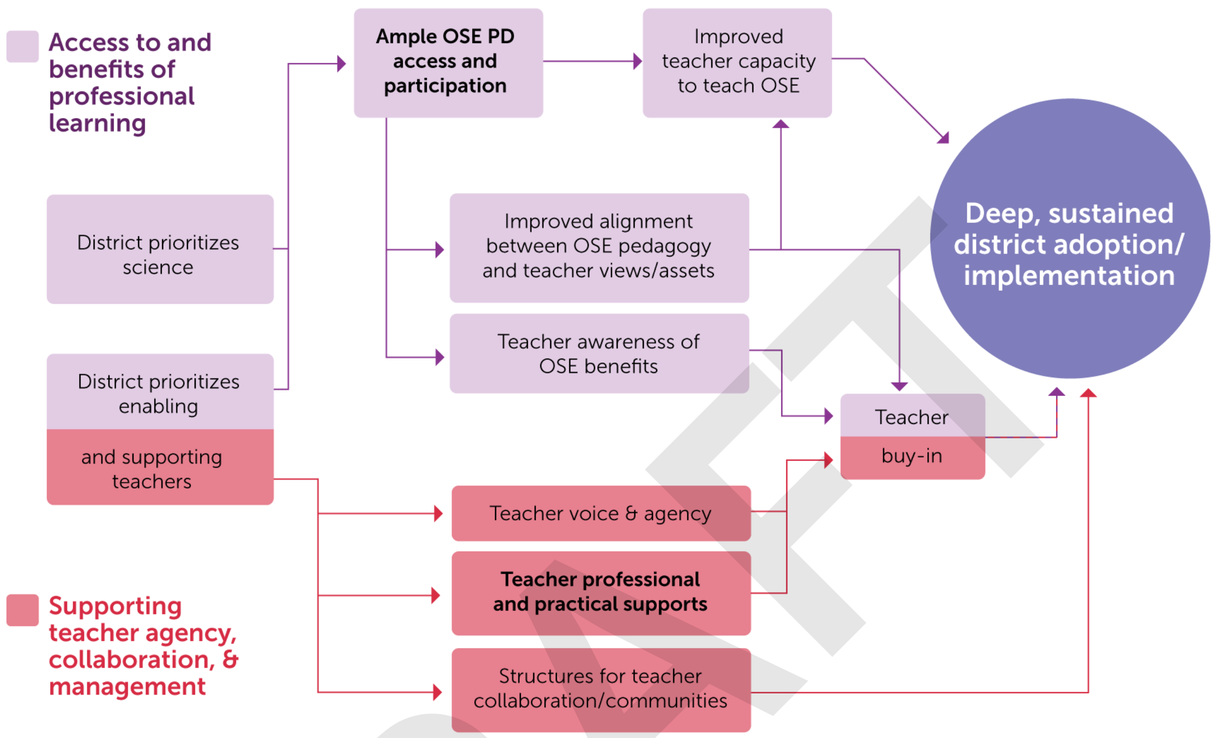
Finding 4: Practitioner needs related to deep, sustained district adoption and implementation gave rise to two themes: (1) access to and benefits of PL and (2) supporting teacher agency, collaboration, and management.

Our map of practitioner needs related to district adoption and implementation appears in Figure 2. We identified two high level themes from the needs practitioners identified related to adoption and implementation. Related to the theme of practitioners' **access to and benefits of PL**, the fundamental needs at the district level are the prioritization of science as a discipline and of enabling and supporting teachers (Figure 2, left). These fundamental needs enable teachers access to and participation in OpenSciEd PL, in turn enabling districts to meet a range of other needs such as improving teachers' capacity to teach OpenSciEd, improving teachers pedagogical alignment with the OpenSciEd instructional model, and raising teachers' awareness of the distinctive benefits of OpenSciEd. Pedagogical alignment and teacher awareness of OpenSciEd benefits in particular enable teacher buy-in.

Related to the theme of **supporting teacher agency, collaboration, and management**, the fundamental need is a district culture of enabling and supporting teachers. This culture enables teacher agency in district implementation and classroom enactment, providing teachers with necessary professional and practical supports for enacting OpenSciEd, and enabling teachers to collaborate and participate in professional communities. Teacher agency and practical and professional supports in particular help enable teacher buy-in to OpenSciEd.

Figure 4

Map of OpenSciEd (OSE) practitioner needs for enabling deep, sustained district adoption and implementation. The needs in bold occur across all three maps.



Vignette: Teachers who are highly experienced with traditional science instructional approaches may have distinctive PL needs.

As expected, numerous teachers and leaders pointed to the role of OpenSciEd PL in improving teachers' capacity to enact OpenSciEd by developing teachers' knowledge of the Science Framework and supporting teachers in enacting practices and routines aligned with OpenSciEd's distinctive instructional model. The following exchange between two district leaders (L1 and L2) highlights the potential role of PD in supporting teacher buy-in, especially with teachers who are accustomed to non-practice-based science pedagogy.

> L1: We started discussing [OSE implementation] last school year. ...We have a lot of teachers [saying they] don't wanna change. ... We've slowly been opening that door a little bit, and they're starting to see the rationale and the reasons behind it. ... And it's gonna take a lot of professional learning to get them to understand three-dimensional learning. ... That's not what they've done all these years. Especially our experienced teachers sort of push back against that a lot. And we need to really work to build that capacity so they do understand us.
>
> L2: It's interesting 'cause I saw the younger teachers who are just entering the profession; they are lacking in capacity because they are trying to do 10 trillion different things all at once. They're learning how to teach. ... the more experienced teachers are like, I don't have the capacity to learn something new. ... Amongst two different populations of teachers, those who

> have taught fewer than five years and those who have taught more than five years, and addressing both of those unique populations' needs requires a lot … of professional learning, and you need very targeted and tailored professional learning.
>
> L1: … A lot of it is lack of professional development, as a lot of districts just don't have the funds. … We don't have the capacity because schools have so many other things that are thrown on their plate now, so many mandates that are coming from state or federal or wherever else that the time and the effort is not spent on [PL].

In this vignette, both leaders agree that they observe more resistance from some experienced teachers to OpenSciEd buy-in. L2 suggests that the PL needs of experienced teachers who are accustomed to traditional instructional approaches may be distinct from those of new teachers. L1 points to a lack of resources that are needed to offer sufficient PL opportunities to shift teachers' views toward practice-based pedagogy.

Vignette: Teachers need a voice in district implementation and enactment policies

The focus group interviews identified a range of ways (in addition to OpenSciEd PL) that teachers needed to be supported by their districts. These included other PL opportunities, support for finding and accessing OpenSciEd resources, and time and space for peer collaboration. One district leader elaborated on the importance of giving teachers a voice in how OpenSciEd is implemented and enacted district-wide:

> So these are the things that we're saying everybody is absolutely going to do because we all believe that this is good for students. And then what are some of the things that you can have some flexibility around or some autonomy? As far as the lesson sequence and the timing, that was something that we said was a little more negotiable. … [Teachers] felt like they had some say in what was going to be most important. And they understood that it wasn't like … on day 17 of the unit you should be on Lesson seven, part two like that…. We all want the same thing: positive outcomes for students. And so it kind of took allowing them to have a seat at the table to make some of the decisions.

This leader describes a district implementation approach that, rather than imposing strict guidelines on teachers in a top-down fashion, promotes teachers' agency in the process. The approach balances a strong emphasis on the core principles of OpenSciEd enactment with "negotiable" elements of enactment, which acknowledge teachers' need to make certain decisions and rely on their expertise and judgment when making pedagogical decisions. Together, the two vignettes point to the importance of valuing teachers' assets, which could be especially helpful for creating buy-in from experienced teachers accustomed to non-practice-based science pedagogy.

Finding 5: Practitioner needs related to high-quality, equitable classroom enactment and student engagement gave rise to three themes (1) improving teacher capacity to teach OpenSciEd (2) meeting students' needs, and (3) shifting classroom culture.

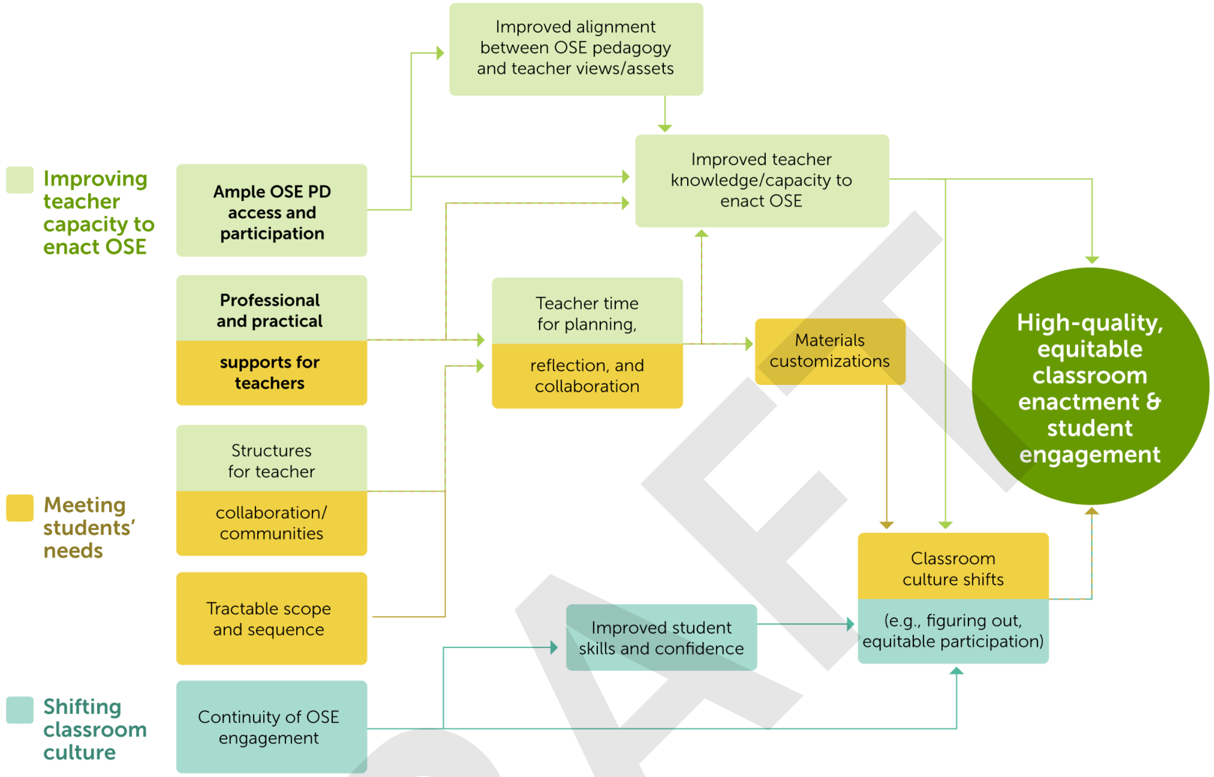
Our map of practitioner needs related to high-quality, equitable classroom enactment and student engagement appears in Figure 3. We identified three high-level themes from the needs practitioners identified related to enactment and engagement. Related to the theme of **improving teacher capacity to teach OpenSciEd**, the fundamental needs were teachers' access to and participation in OpenSciEd PL, professional and practical supports for teachers, and enabling teacher collaboration and communities. These basic needs help align teachers' pedagogy with OpenSciEd's instructional model and provide teachers with more time for planning and reflection, which in turns improve teacher capacity for classroom enactment.

Related to the theme of **meeting students' needs**, the fundamental needs were teacher supports, enabling collaboration, and defining a tractable curricular scope and sequence. Together, these needs give teachers the planning time they need to customize instructional materials to their students' needs, thereby enabling all students to engage in figuring out phenomena and classroom discussions.

Related to the theme of **shifting classroom culture**, the fundamental need was enabling students to continuously engage with OpenSciEd (from one unit, grade, or grade-band to the next). This continuous engagement enables students to improve skills (e.g. science practices, science discussions) and their confidence with engaging those skills. Improved student skills and confidence are needed in order to foster the culture shifts that are distinctive to OSE.

Figure 5

Map of OpenSciEd practitioner needs for enabling high-quality, equitable classroom enactment and student engagement. The needs in bold occur across all three maps.



Vignette: Teachers need support for accessing and customizing materials in order to meet students' needs.

Many teachers pointed to the amount of time they spend customizing student-facing materials, especially to meet the needs of MLs, students with disabilities, and any students who require additional supports to engage in practice-based instruction. Examples of customizations include providing linguistic supports such as sentence starters, translating materials to other languages, or adding additional scaffolds for classroom tasks or assessments. One teacher described the range of factors that contribute to the amount of time required to customize materials:

> I have the most IEPs I've ever had, [some are] extremely specific on ELA and math goals, and this curriculum is very heavy on reading and math. … Those kinds of things in a class of 32, and I don't have a TA, and we don't have co-taught science—it is super challenging this year. So it takes a ton of preparation outside of class for those kids. … But then this year we stumbled on the distance ed versions. And those actually have way more modifications on it for the first few units in all the grade levels. … But I don't like how much time [it takes] to search for things.

In this brief excerpt, this teacher points to numerous factors, such as (1) the number of students with special needs, (2) supports students need for reading and mathematics, (3) large class sizes and lack of support from assistants to manage large numbers of students, (4) lack of opportunities to collaborate with other teachers, and (5) the time required to search for supplementary resources. These factors illustrate the range of supports teachers in particular need from their administration in order to invest time necessary to prepare to teach OpenSciEd lessons to students with diverse needs. These needs also represent opportunities for researchers to investigate how best to provide these supports and for developers to create supporting resources for OpenSciEd teachers.

Vignette: Shifting classroom culture requires continuity of engagement, enabling students to develop skills needed to engage in OSE successfully.

Numerous teachers pointed to the amount of time students require to develop skills needed to figure out phenomena, participate in classroom discussions, and generally engage deeply in the science practices such as conducting investigations, analyzing data, and developing models. Teachers observe that these skills develop with ongoing engagement in OpenSciEd over the course of a year, a grade band, or potentially even across grade bands. One teacher who taught OpenSciEd to sixth and eighth graders remarked that students who did not have OpenSciEd in seventh grade had to relearn the OpenSciEd culture in eighth grade. As a result, the teacher requested to teach sixth and seventh grades in order to develop student skills continuously across the two grades. Another middle school teacher observed challenges of students having very little science instruction in elementary school:

> I guess I'm not fully implementing [the science circle] either because it's very hard for [students] to transition from where it's more teacher-led instruction to student focused instruction.... They're struggling with just getting their thinking out there because they're not confident. ... And they're still in the mode of no, there's a right answer, there's a wrong answer, and I have to be right.... In the elementary schools, science gets kind of pushed to the back burner because it's not math and reading, and if they teach science or they teach social studies in elementary school, it's more reading-based, and there's not a lot of investigations and experiments to do, or if it is an experiment, it's very controlled. So they're not confident in their science in general.

This teacher identifies students' confidence with voicing their own ideas, willingness to be wrong, engagement in science practices, and participating in discussions as obstacles to developing an OpenSciEd classroom culture. The teacher points to students' lack of elementary science instruction or opportunities to figure things out ("controlled") as underlying reasons for the challenges students experience with OpenSciEd in middle school. These are skills that several teachers named as essential to develop through consistent engagement with OpenSciEd over time. These remarks point to potential benefits of full district adoption (including across grade bands) and to the need for research on the impact of full district adoption on student outcomes.

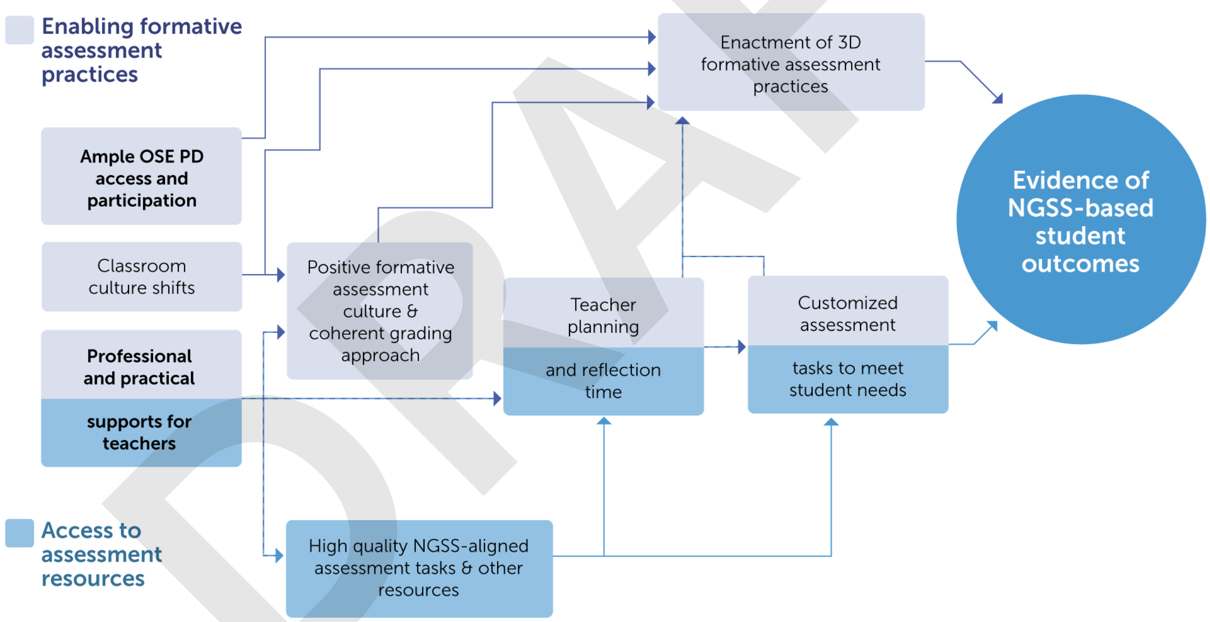
Finding 6: Practitioner needs that enable evidence of NGSS-based student outcomes revolve around two themes: (1) enabling formative assessment practices and (2) access to assessment resources.

The map of practitioner needs related to evidence of NGSS-based student outcomes appears in Figure 4. We identified two high-level themes from the needs practitioners identified related to enactment and engagement. Related to the theme of **enabling formative assessment practices,** the fundamental needs are practitioners' access to OpenSciEd PL, classroom culture shifts, and other professional and practical supports for teachers. Assessment-oriented PL activities and classroom culture shift toward figuring out phenomena and discussion can enable teachers to enact formative assessment practices. This classroom culture shift, aided by support from school or district administration, can also enable a positive formative assessment culture where students voice their ideas, revise their work, and focus on growth rather than their grades. Administrative support also gives teachers more time to enact time-intensive formative assessment practices such as evaluating student artifacts and giving individualized feedback.

Related to the theme of **access to assessment resources**, schools and districts can support teachers by helping them find assessment resources such as tasks, rubrics, and tools, including those that meet the needs of particular student groups. These supports reduce the time teachers must spend customizing tasks for their students' needs.

Figure 6

Map of OpenSciEd practitioner needs for enabling evidence of NGSS-based student outcomes. The needs in bold occur across all three maps.



Vignette: Teachers need support to implement a grading approach that is coherent with goals of formative assessment.

A core principle of the OpenSciEd system of assessments is that assessment tasks are coherent with the instructional model—that is, assessment tasks engage students in the three NGSS dimensions and, as with instruction, they are anchored to science phenomena. Students should not halt their process of figuring out in order to be assessed. As such, assessment approaches that are coherent with OpenSciEd's instructional model are at odds with typical grading expectations, which tend to emphasize summative (rather than formative) assessment.

Several teachers described their difficulties with assigning students grades based on the work they do in OpenSciEd units:

> My challenge comes from the fact that we're not a standards-based grade system. So I have to try to figure out what constitutes a letter grade? … I have to have a grade for their report card and be able to have evidence if it's not an A you know, like parents [are] upset if it's not … the grade that they would like them to have?
>
> . . .
>
> Most of my grading comes from their participation, their discussions. I don't grade their notebooks, but I grade little exit tickets or things like that just because I need a grade in the grade book.

Challenges like the ones described by this teacher are well documented. For instance, OpenSciEd created a page on their website specifically for the purpose of providing guidance for teachers on grading (OpenSciEd, 2024). The resources on the website provide a helpful framework, tools, and perspectives from teachers for implementing grading approaches that are coherent with OpenSciEd instruction. However, these approaches will necessarily be specific to instructional contexts. As such, school and district administration must also provide guidance for teachers on how to implement grading approaches that respond to local policies and expectations.

Vignette: Teachers need support for accessing assessment resources in order to feasibly provide helpful feedback to students.

A trade-off to making assessment coherent with instruction is that high-quality, phenomenon-based, three-dimensional assessments can be challenging for students and time consuming for teachers to grade and provide feedback. Two recurring themes related to assessment were (1) the need for ready access to assessment resources that meet the needs of specific learners, particularly MLs and students with disabilities, and (2) the amount of time needed to evaluate students' work products and provide helpful feedback:

> How do I [give feedback] so that the students accept the feedback and they make changes based upon it? So one thing that I do is I voice record feedback … because tone matters, and when you can say it to them in a positive way, we can learn how to accept critical feedback and make changes. … And it's taking me two minutes per student to voice record feedback times 200 students, plus. I have to read them and decide where they're on a rubric. … But most teachers … they're like, I'm not [doing that].

This excerpt raises a couple of important issues related to the classroom feasibility of three-dimensional, classroom-based assessments. First, this teacher identified the need to invent their own system of feedback involving voice recordings so that students would receive the feedback in a positive and constructive way. Second, the amount of time required to evaluate the response and provide constructive feedback for a large number of students can make certain formative assessment practices prohibitively time consuming. These challenges are general to three-dimensional assessment (e.g., Pellegrino, 2013) and are not specific to OpenSciEd. However, OpenSciEd's approach to making assessments coherent with instruction make it an appropriate curricular context for researchers and developers to devise and study classroom feasible three-dimension assessment solutions for teachers.

Limitations

We discuss three key limitations of this study. First, the OpenSciEd practitioner needs we identified reflect only what our teachers said in the surveys and interviews; the maps do not include theory-based conjectures about practitioners' existing needs or connections among them. We also do not include practitioner needs identified from other empirical studies. As such, some existing practitioner needs may not appear in our maps.

Second, the insights reflect the experiences of only middle and high school practitioners because OpenSciEd materials are currently available for these grade bands, as of this writing. OpenSciEd elementary materials are currently under development. We acknowledge that elementary practitioners and districts may have very different needs from those in middle and high school contexts. The extent to which our insights generalize to elementary contexts is unclear and warrants additional study.

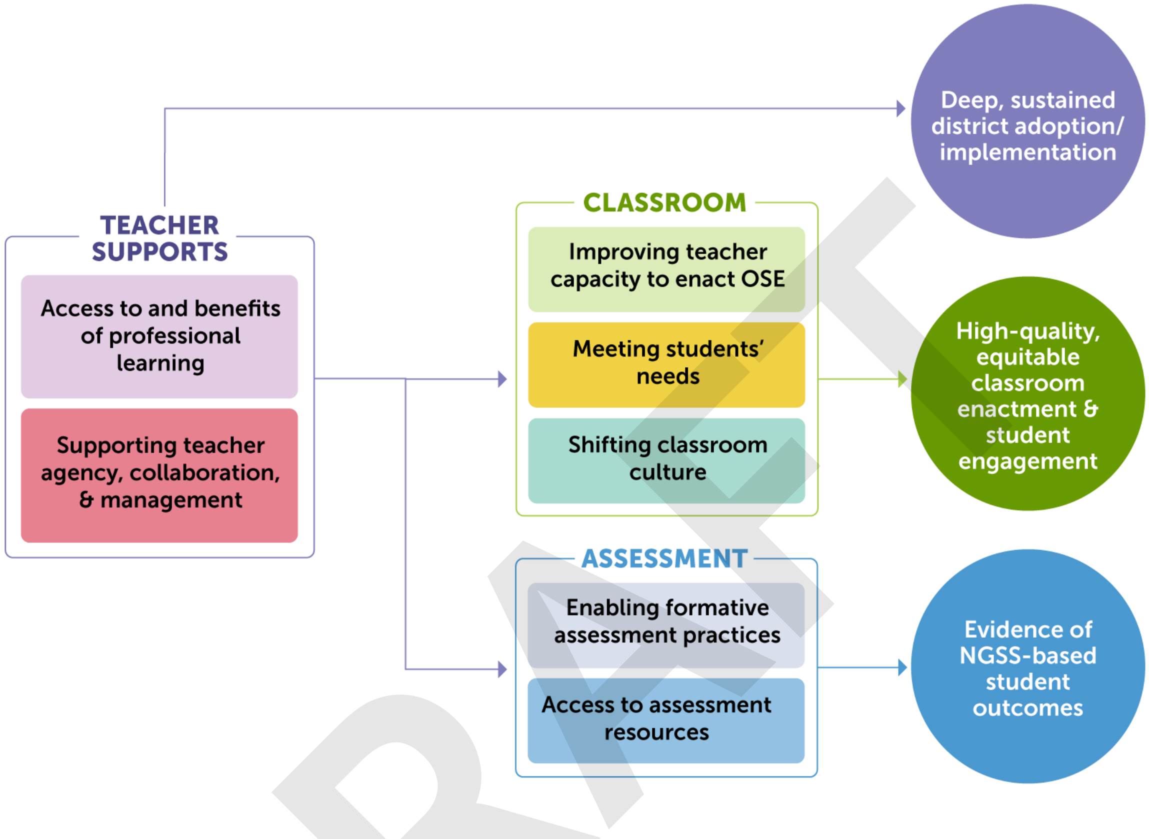
Third, most of our respondents were recruited to participate through OpenSciEd networks, and many took part in the OpenSciEd field tests. A large portion of the respondents have therefore chosen to implement OpenSciEd (as opposed to implementing it at the request of others). These respondents likely have a generally positive orientation toward the materials and the underlying instructional principles. As a result, our respondents' views may not be representative of all OpenSciEd users. For the purposes of this study, we believe that gathering perspectives from practitioners who are deeply invested in OpenSciEd by their own choice is appropriate.

Priorities for OpenSciEd Research, Innovation, and Development

Figure 5 combines the themes from Figures 2–4 into a single map illustrating how the seven themes are related to the three broad outcomes. Practitioners identify professional support for teachers to be foundational to meeting needs across the system levels. These supports include not only curriculum-based PL but also other PL opportunities, support for management and collaboration, and supporting teachers' voice in adoption and implementation decisions. Practitioners indicated that meeting these needs could enable not only deep and sustained district adoption but also other needs related to classroom enactment and NGSS-based classroom assessment. In particular, OpenSciEd PL and other professional and practical supports for teachers appear to address root causes of many challenges experienced by practitioners, pointing to the need to increase investments in these types of supports. These findings illustrate the potential impacts of a robust system of teacher supports and justify substantial research and development investments in them.

Figure 7

High-level view of all three OpenSciEd practitioner needs maps showing how all seven major themes relate to the three broad outcomes. Meeting teacher support needs (yellow box) is foundational to achieving all three broad outcomes.



Our analyses point to potential opportunities for OpenSciEd research, innovation, and resource development. Collectively, the OpenSciEd practitioner needs maps constitute a kind of conjecture map (Sandoval, 2014) that can guide researchers in gathering empirical evidence of the relationships expressed in them. For practitioners and policymakers, the maps identify "levers" that leaders can pull to effect change in their respective systems. For developers, the maps point to resources and tools that can meet OpenSciEd practitioners' needs. Based on the analysis, we identify the following five broad and interrelated priority areas for OpenSciEd research, development, and innovation; we provide a few examples of promising directions for each area.

Providing resources that support teachers' classroom enactment and formative assessment

High-quality supporting resources meet teachers' needs in myriad ways. Teachers report spending a great deal of time searching for and adapting materials to meet the needs of their classroom contexts and students (especially MLs and students with disabilities). Easily accessible resource repositories could dramatically reduce this time, enabling teachers to increase time devoted to other enactment-related activities. Assessment-focused PL and assessment tools (e.g., tasks and rubrics) could grow teachers' assessment literacy and augment their repertoire of classroom assessment practices. Researchers should also investigate the capacity for emerging technologies to support assessment and enactment. In addition to currently existing technologies that can automate scoring, feedback, and reporting on complex students, AI-based technologies could also support distinctive aspects of OpenSciEd enactment, such as classroom discussion facilitation or materials adaptation.

Identifying promising models for district adoption and implementation

Research should examine adoption processes and implementation practices that can sustain classroom culture shifts and teacher buy-in and growth. For example, districts defining a tractable scope and sequence for teachers, especially in the initial years of teaching OpenSciEd, can give students class time necessary to engage in figuring out and enable teachers' successful transition to OpenSciEd pedagogy. New district organizational structures could support teachers with practical needs (such as locating resources, obtaining supplies, and adapting materials) and enable teachers to benefit from coaching, collaboration, and participation in professional learning communities. Implementation models can value teachers' assets as educators, encourage teacher autonomy in ways that are consistent with OpenSciEd broader pedagogical model, and promote teachers' agency by giving them a voice in district implementation practices.

Promoting classroom culture shifts in science

Classroom culture shifts emerge as a particular outcome that merits further study. These shifts will likely require deep, district-wide adoption where students experience the storyline-based science instruction continuously and across grade bands (ideally from kindergarten to grade 12). This culture shift will require students and families to shift expectations about science instruction. These expectations will need to include unit-long focus on explaining a phenomenon and viewing iterative refinement as a growth process rather than repetition. Culture shifts must also encompass views of assessment as being growth-oriented rather than merely evaluative. Some aspects of this desired culture already exist in other disciplines—for instance, language arts classes often spend weeks discussing a novel, while ongoing revision is an expected practice in computer science. Effecting these types of classroom culture shifts in science offers a fruitful area of focus for research on OpenSciEd district implementation.

Conducting efficacy studies

The practitioner needs maps identify implementation conditions and mediating factors for potential efficacy studies on OpenSciEd. The practitioner needs point to teacher and district supports that would be required (such as access to PL and instructional resources) in order to examine implementation and instruction under "ideal circumstances" for an efficacy study (Institute of Education Sciences and National Science Foundation, 2013, p. 9). The practitioner needs also identify factors (such as collaboration structures or indicators of district culture) that could mediate student and teacher outcomes.

Promoting broad systems change

In addition to the above four priorities, we see a fifth priority that is latent in the other four priorities, but it is worth studying on its own. This study identifies numerous OpenSciEd practitioner needs that education systems currently struggle to meet. These gaps call for research on how OpenSciEd gives direction to and creates pressure for broad systems change that can better support phenomenon-based science instruction. Finding ways to meet these needs could help promote sustainability and continual improvement of science education systems, enabling teachers to fully realize OpenSciEd's vision.

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