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Partnering with Users to Develop STEM Education Materials: Insights from Discovery Research K-12 Projects



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Partnering with Users to Develop STEM Education Materials: Insights from Discovery Research K-12 Projects

This brief suggests practical ways of engaging teachers and other “end-users” in projects that develop materials for education in the areas of science, technology, engineering, and math (STEM). It describes the experiences of sixteen development projects in which research and development (R&D) professionals invited active end-user participation. Contributors to this brief have found that partnering with end-users not only served conventional purposes, such as easing access to pilot sites, but also offered unexpected, useful insights for the development process. It organizes insights by the following thematic sections:

- Purposes for User Engagement
- Planning for User Engagement
- Recruiting Users as Partners
- User Relationships and Communication
- Concept and Content Development
- Gathering Feedback from User Participants

Contributors to this brief have worked on a variety of DR K-12 projects funded by the National Science Foundation. Their projects differ in their intended end-users, types of materials being developed, and the size or scope of the work. Many targeted particular types of teachers as end-users, though some were developing products for use by others such as students, district professional developers, and gatekeepers at various educational levels. The projects set out to develop different types of STEM education materials including large curricular sets, standalone lessons and units, technology-based games, professional development materials, and online lessons. Informed by their different project experiences and goals, this group of contributors provided a breadth of insights, as well as evidence that there is no one set of strategies for partnering with users.

In each case, the project’s R&D purpose was to develop materials that would effectively serve its aims related to student and teacher learning. A rigorous process of expert development and testing shaped products that could demonstrate the intended outcomes. But products do not implement themselves in the field. Users must adopt them and put them to work in classrooms or other settings. Implementation consists of the teacher’s use of the materials and the learner’s interaction with the content and presentation. When teachers and students participate in the development process, they offer a window into implementation—and this brief reflects the conviction that the window should be opened as wide as possible. Doing so results in the development of better materials that are more likely to be used.

Purposes for User Engagement

Most if not all development projects in STEM education bring users into the process in at least a cursory way, as test subjects. Observing users’ interactions with draft or prototype



materials, measuring the results, and revising the materials are steps in the development process. The authors of this brief have found, however, that users' longer-term and deeper engagement, well beyond the role of test subjects, can serve other purposes as well. In their own projects they found that working with users helped them address objectives that ranged from simple to complex. Users helped the project teams:

- Better align products with priorities of schools, districts, or states
- Reframe the problems from a user perspective, and position the materials as a solution
- Correct flawed assumptions about teachers' or students' capacity and motivations
- Fine-tune the format, language, and overall usability of learning materials
- Gain entrée to test environments
- Identify optimal levels and types of supports needed by users
- Support adoption within authentic settings
- Determine and promote the right balance between fidelity and adaptation
- Contribute to sustained or scaled implementation in particular sites
- Establish a corps of trainers or mentors who can help in rolling out the project to additional sites

The next few sections of this brief present practical suggestions for productive user involvement in the development process. These suggestions are distilled from the group members' positive and negative experiences, mistakes made, serendipitous discoveries, and lessons learned.

Planning for User Engagement

Planning for user engagement, and project design in general, benefits from nuanced clarity in identifying the project's target users. Early efforts to identify the target audience might include weighing the benefits and drawbacks of defining a narrow target group. The project team might specify which types of students and teachers will most likely benefit from the materials, while other types may be secondary. It might also specify the characteristics of schools and districts that are most likely to adopt the materials or effectively sustain implementation. (See the next section, "Recruiting," for more on types of users.) With a profile of end-users in mind, project leaders can begin to think about how to involve users as development partners.

Early in project design, a project team should brainstorm purposes for involving various practitioners and the specific types of involvement that could help the project. Amid project start-up concerns, it is easy to short-change strategic thinking about how users might best contribute to development processes. Although different purposes and opportunities may emerge along the way, the team should consider questions such as these: Do we want input on conceptual issues, such as clarifying the problems of practice that the project will help solve? Do we have existing materials that need testing and refinement? Are we open to substantive changes in project or product design, or are we committed to existing plans and constructs? How important is usability feedback for our development? Do we want input on marketability and



alignment with the contextual priorities of potential adopters? Such an exercise can help determine how to approach the recruitment and involvement of end-users.

There is a risk in waiting too long to get user input. The further a project goes down the development pipeline, the harder it becomes to make changes, both practically and in terms of the emotional momentum. It also may become more difficult to gather useful input on substantive design issues. Users from schools and districts can often see flaws that have serious ramifications for implementation and sustainability, for instance the material's alignment with key policies and curricula. Users, however, may also have practical insights as to format and delivery that will not rise to the surface until later in development.

One teacher I know is involved in a project and she's frustrated because it is step-by-step and here is how you do everything. And they want feedback on does step number three work. What she wants to do is tear the whole thing up and use the science, but teach it in a different way. But they are not asking for that. The whole project is not structured to get her feedback in a way she is comfortable with. And that is what I started with—the whole idea that teachers should be colleagues and collaborators.

Trautmann

I found it was less effective to develop something and then show it to teachers and say, "So how do you like it?" It would make much more sense to start off with "What do you need, and what can we work on together?"

Scotchmoor

An option worth considering at a very early stage is that of putting end-users in leadership roles or paid staff positions on the project. In these positions, they have greater authority behind their contributions. They can help ground design and implementation decisions in the realities and perspectives of target users. They can also help the project integrate with existing priorities and programs specific to their institutions, while providing perspective on how products might be regarded or adapted by districts and schools. Pruet's project, working closely with and within a city school district, recruited its deputy superintendent as a Co-Principal Investigator (Co-PI). Other current or recent district employees, such as content area supervisors, served in implementation or advisory roles.

Some of our work group members actively sought out district staff and teachers who were recently full-time in the classroom to join the project as Co-PI and task managers. These individuals were brought on to the project to be involved intimately and over the long term, typically under a contract or a leave arrangement with their district. Some of these partners may have been interested in a career shift out of the K-12 school setting, but others took a temporary or part-time leave and intended to return to their school or district positions to help sustain and scale local implementation of the project. Wyner, who planned the project while a K-12 teacher herself and became the project PI, has found that her teaching experience and perspectives have helped orient project design to the needs and constraints facing target users. It has also helped her strategically identify current teachers who could serve on an ongoing basis as design and testing partners.

By including target users on project advisory boards, a project can efficiently gain practical insights from savvy "friends" of the project over time and as needed. Advisors can



provide input at various stages of the project and on a variety of topics, and projects have some flexibility in drawing from specific advisors for specific purposes. Some of our work group members have incorporated practitioners on advisory boards to balance and complement content or research experts. Scotchmoor found it beneficial to set up separate advisory bodies according to purpose and member role—in this case, one board focused on ensuring content quality, and a second consisted entirely of teachers who provided user perspectives on issues such as usability, relevance, and potential adaptations. Furthermore, she “cross-fertilized” the two boards, finding it critical to include some representation of each group at both types of meetings (i.e., content reviewers at the teacher meetings and teachers at the content meetings).

Advisory boards also provide a promising role for users who can be described as “gatekeepers” or “decision-makers,” namely school and district leaders. These partners can be instrumental in providing instrumental feedback on policies and other contextual features that may enable or hinder adoption, implementation, and sustainability after the grant is finished. Their involvement may also convert them into advocates when unanticipated barriers arise. Ault recruited state and district science supervisors to serve on an advisory board to give early input on game concept and content.

Regardless of their role, project staff who are current or recent practitioners can be instrumental in getting key tasks done. They better understand the contexts in which DR K-12 projects are often rolled out, including the players, pressures, politics, infrastructure, instructional program, and institutional memes. They may have allies, carry credibility with participants, and enlist the buy-in of decision makers. They may be able to help navigate unforeseen obstacles and facilitate sustainability, particularly amidst turnover.

For active practitioners to contribute fully to a project, the project must treat them as partners and bring them onboard in substantive roles (e.g., lead trainer, field-test coordinator, debrief data collector). For example, Pruet hired a recently retired teacher as a project coach to help teachers test curricular modules. This coach ended up serving as the face of the project in the district. In several projects, teachers who were key project members made a transition to leading training and mentoring later participants.

End-users who are project leaders or advisors can be well positioned to lead work after the grant or initial R&D cycle is finished. In *Developing Inquiry-Based Science Materials* (2001), Thier describes the work of former district employees helping to turn field test sites into implementation centers that can support, sustain, or spread the ongoing local use of the project’s materials (p. 179). Some take on leadership roles in disseminating project knowledge. Scotchmoor and others have worked with practitioner partners whose intimate involvement throughout the project later included conducting presentations, writing papers, and strategizing on broader use of the project’s products.

Thier suggests that a project might consider buying a part of the teacher’s contract from the district to protect the individual’s job security and promote a partnership with the district (p. 80). Such an arrangement also helps ensure the project is recruiting a colleague who has the perspective and identity of a current teacher. Similar arrangements can be made to formally



enlist district staff, such as content area supervisors and professional developers, and to protect their commitments to the project.

Recruiting Users as Partners

After giving thought to what a project needs to learn from users and the roles that appropriate types of users should play, the project team can then clearly communicate their intentions when recruiting partners. Early communication should include details about the tasks, commitment, timeline, and desired characteristics of participants, not to mention an overview of the project's goals and vision.

Several contributors to this brief pointed out that the most valuable feedback sometimes comes from teachers who are less likely to volunteer or are not particularly passionate about the subject or pedagogical approach. Projects may benefit from a recruiting strategy designed to pull in teachers who may not be the obvious or easiest choice. Helpful user partners may be those who are unlikely to volunteer or apply to participate in a particular R&D project, or those who do not regard the project's content or pedagogy as a personal passion. These teachers, more likely to have a healthy skepticism and sensitivity to competing pressures, may provide feedback that is a needed reality check.

However, in identifying teachers to give input, projects often find it easier or more productive to recruit the most highly motivated and willing teachers. These teachers, though probably not representative of the project's target users, are likely to invest themselves in the project and sustain involvement. Particularly when relying on atypical motivated users, it is wise to keep in mind how they differ from the target user and the implications that has on the materials.

Well, the teachers who are going to be contributing [to development] are usually passionate, and it is true that it would be nice if all teachers were that passionate. But that's not the case. Sometimes the best we can do is take those who are passionate and create products that engage others with different levels of passion.

Scotchmoor

Another group of teachers to consider actively recruiting are those who have less experience, expertise, confidence, or authority in their work. These teachers are a substantial portion of the profession, and often, these are the teachers whom projects are targeting or who are more likely to end up using the materials. Yet they are less likely to volunteer for or be recruited by an R&D project.

With a lot of the cutting-edge educational resources being developed, it's the superstar teachers who volunteer for those programs and help to develop the materials and implement them. But then will they ever be useable by all the teachers who teach that subject? I don't think people are really confronting that issue.

Trautmann

Involving a wider range of teachers can give insight to problems that target users may have. For example, Miller's field testers had a broad range of experiences and expertise, and



they represented her target user group of teachers with two to five years in the profession. Some of the most valuable feedback came from teachers who had trouble and were willing to help build solutions to their problems into the materials.

We don't want to write curriculum just for exemplary teachers. We really wanted to make it accessible to all teachers, but that did not happen until our field test...The ones who struggled, I think that they really were the teachers whom I found most useful in some ways, because they pointed out places where we really needed to support their implementation through the materials.
Miller

Several group members, including Miller, Trautmann, Casa, and Gavin, have suggested differentiating the types of teachers recruited based on the project task and stage. For example, uniquely motivated and skilled teachers might be particularly informative during early development as deeply involved partners who write content or help shape pilot iterations. Teachers who are more typical or closely match the target users might be helpful in field testing and refining materials.

When possible, recruit teachers through a competitive application process that makes participation enticing while garnering committed partners who meet the project's needs. Trautmann's application criteria are designed to be specific and meaningful, and based on the purposes for partnering with them. Competitive application processes are more effective when there is a large pool of interested candidates, which is why she invests in an ongoing way in building a network of potential partners. Trautmann and others have also crafted advertisements that while selling applicants on the attractive features of participation, also provide details on the desired commitment and characteristics of participants. Hsu and Wang were confident they had committed teachers after recruiting through both nomination and competitive application processes.

With your project's purposes and target users in mind, be strategic in who you recruit as development partners, prioritizing specific characteristics. The R&D team might want to use any of the following criteria in identifying partners to work with:

- Teachers:
 - Teaching assignment, past and anticipated (grade level; content area; class size; total student case load; special populations such as honors/gifted, English language learners, and special education)
 - Years of teaching experience
 - Motivation and interest in project, such as its pedagogical approach, content, and expected tasks
 - Mastery of teaching profession (as indicated by credentials, recommendations, leadership positions, performance on standardized measures)
 - Content knowledge
 - Technological expertise and access
 - Type of school (geographic location; enrollment size; student demographics including poverty; student academic performance; curricular foci and special programs; instructional and professional development schedules)



- Students:
 - Reading level
 - Content knowledge
 - Technological expertise and access
 - Motivation and interest related to content
 - Underrepresentation in particular career pipelines

- District staff (including those in departments responsible for instruction, professional development, research, and accountability and data):
 - Organizational authority regarding curriculum adoption, teacher professional development, school-level instructional decisions, and data sharing
 - Content knowledge and interest
 - Professional developer expertise
 - Data systems expertise

An R&D team may want input from end-users who work in various states and types of districts, particularly if the project's materials are intended to be used broadly. Policy and operational contexts have a bearing on user perceptions of relevance and usability. Participant end-users can provide useful information about how academic standards, existing curricula and pedagogical approaches, and authority structures influence what materials will be picked up by target users and how they will use them.

Prior to recruiting, project leaders should weigh the benefits and drawbacks of partnering with a school team versus an individual from each site. For project tasks such as pilot and field testing or joint content development, Wyner has found that there are advantages to working multiple participants in a school. When school-based teams are involved, participant discussion about implementation and challenges can be ongoing, job-embedded, and more easily supported by the project, all improving feedback. Also, there may be logistical advantages to grouping participants at schools, allowing project leaders to meet with and learn from teachers more frequently. Individual engagement and sustainability may be improved through group processes, particularly if a localized community of users grows around a project. Lastly, with a school team, it may be possible to enlist participants to help recruit others who are less likely to volunteer on their own, yet who have valuable perspectives on project materials.

On the other hand, recruiting individuals may make more sense if the project will benefit most from participants who are unique in a needed way, such as being highly motivated or meeting very specific criteria (e.g., content expertise, experience, work with particular populations). It is also likely a project would want to recruit individuals who are candidates for deep involvement on the project, such as teachers on special assignment or who are contracted by the project. Zucker, wanting co-developers who were skilled and experienced, recruited math and science department chairs. Gray, whose materials were particularly unique in content and pedagogy, partnered with music and science teachers who were open-minded and willing to collaborate outside of their content-area comfort zone. Some projects may recruit both individuals and teams, differentiating their roles according to project purposes and stages.



Several contributors to this brief said there are often benefits to strategically recruiting gatekeepers, such as district content supervisors and professional developers. Their input as advisors or Co-PIs can be invaluable for developing the product concept, securing buy-in, navigating forces that could adversely affect implementation, and preparing for future adoption and sustainability. Ault, in addition to developing ongoing partnerships with students to refine an educational game, recruited state and district science supervisors to serve on an advisory board and give early input on game content. Pruet partnered with a district deputy superintendent serving as a Co-PI, as well as with district math and science supervisors, to get ongoing input on product design through feedback on alignment between module frameworks and the district's learning objectives. Hsu and Wang recruited school- and district-level contacts to identify a pool of potential field testers.

User Relationships and Communication

In order to help users see what their role on the project will look like, and to understand how their feedback will be used to inform the product, consider sharing a clear timeline and task list with users at the outset and at periodical updates. While some level of detail was likely shared as part of their recruitment, contributors to this brief found benefits in ongoing communication that clarified user tasks and how their efforts relate to the broader project plan.

An early and ongoing priority for a productive partnership is cultivating an environment in which end-user participants feel welcomed and respected. While most R&D leaders probably agree with this sentiment, contributors to this brief suggest you cannot overemphasize the importance of trust for getting honest substantive input. Unfortunately, many projects have a top-down approach that, sometimes unwittingly, suppresses end-user input or treats it as a formality. The premise behind this brief is that users can provide unique and valuable insights for improving development of education materials, yet users will be reluctant to share their insights if they remain unconvinced that they are partners whose contributions are worthwhile.

The fact that teachers were really involved in the process, and were treated as equals along with everybody else who was involved, was really critical. I think it helped us to end up with products that were exactly what a teacher needed and really strong in the science, and that's obviously what we're all after in the end.

Scotchmoor

Compensation of users is one way to signal the worth of partners. While obvious, paying professionals for their time and expertise will help attract and keep valuable partners on the project. Projects often provide stipends, sometimes alongside other incentives, but contributors to this brief suggest thinking carefully about the roles and payment. At the same time, recognize that compensation is just one way respect is communicated.

It goes without saying, but teachers should be treated as professionals. They deserve to be paid. The talented ones, we feel like they're worth their weight in gold and that they really need to be respected as partners.

Zucker



Thier notes that deep partner collaboration requires that project leaders relinquish some ownership of ideas and invite critique from users (p. 102). Brenneman and several others suggested that project leaders should be upfront and honest about what they do and do not know, clarifying where exactly they need help and showing an openness to critique. When project leaders are able to step back and say that they need the expertise of users in order to create the best product, it helps users to see that they are truly needed and that they are expected to make a serious contribution to the work. Scopinich has found this is also true for student feedback, having asked for feedback on “the good, the bad, and the ugly—don’t hold back on your honest feedback, however harsh it may be.”

We were very clear at the very first meeting that this is collaborative. [I tell them,] “I’m not telling you what to do. We need your assistance to make the materials as good as they can be...I haven’t been a classroom teacher. I’ve been in a lot of classrooms, but I’m not going to pretend to know what it is to do your job every day.”

Brenneman

As feedback cycles begin, project leaders should show users how their comments and ideas are being used to improve the materials. Ault has found that when partners—students and teachers—see that their input results in tangible outcomes, they are encouraged to embrace their role as co-developer more fully and feel that they are part of a team effort. Casa and Gavin have found that substantive project changes are evidence for all that being “partners in research” is not empty rhetoric.

We would listen to them, we would go back, we would make revisions to our working prototype and come back and show them, “you said this, so this is what we tried to do. And then you said this, and so this is what we tried to do.”...From the initial paper prototype analysis all the way through working products, they wanted updates on implementation of their ideas, and they suggested innovations.

Ault

Project leaders should design and follow through on communication plans designed to establish and sustain partnerships. Several contributors say that face-to-face group activities can be invaluable for developing a foundation for trust and teamwork with users, which can then be sustained through other communication modes. Several emphasized the need to set routines for ongoing communication, whether by email or phone, so that there is an established link between project leaders and partners and so that users are reminded that their role on the project is needed and valued. Hsu and Wang have used a Facebook page through which teachers and graduate students can network and communicate about project tasks. Zucker has used project management software (in this case Basecamp) to support a multi-state project community capacity to communicate through email, threaded discussion boards, and shared documents.

So we always felt that a face-to-face workshop that brought everyone together also really kind of builds a family, and we’re able to set the tone of, again, “You know, we’re here to help you. We’re working together. We value your time. We respect your feedback.”

Casa & Gavin

Whether the communication between project leadership and users occurs predominantly through in-person or electronic communication, it is important to ensure that project staff charged with working with users are “people persons” capable of establishing rapport with them.



Some contributors to this brief have recruited these staff members from the field or otherwise ensured that individuals in this role will be able to connect with users and understand their contexts. Some added caution to the assumption that project leaders based in universities were the best candidates for this role, though not all teachers can connect with their peers either.

In addition to having an effective staffer in a liaison role, it can also be important for project leaders to address head-on and bridge the potential rifts in cultural norms that may exist between organizations, particularly between the professionals who work in schools and those who work in research. Rather than treat it as a side issue, Scotchmoor addressed cultural differences in joint in-person activities, for instance by discussing the contrasting approaches to feedback used by graduate students and teachers.

We're in a very academic setting. And so with grad students and teachers working together jointly on projects, they have different approaches to providing feedback to one another. So we had to overcome some cultural barriers and differences in just the way they responded to one another's work... We realized we needed to deal with this up-front, and formally.

Scotchmoor

Concept and Content Development

In the process of communicating with users, R&D teams must be open to finding out that they have much to learn. End-users can provide essential input in clarifying the problem and developing the solution concept. Opening conceptual development up to “outsiders” can be difficult for project leaders, particularly if they have already invested their time and passion into an idea. Project leaders also may feel tied to existing materials, theoretical frameworks, and proposal language.

Nevertheless, we believe there are potential benefits for projects when leaders bring in district and school partners to work collaboratively in design. Scotchmoor spent a year working with teachers on special assignment and a teacher advisory board to clarify user needs and develop a conceptual framework. She also surveyed additional teachers to test the project’s understanding of current needs. Important, she says, is that the project team was perpetually oriented toward asking end-users, “What do you need, and what can we work on together?”

End-users can also develop content and author materials, ranging from early prototypes to enhancements of finished products. It is true that writing education material takes unique skills and substantial time, but finding ways to draw on practitioner expertise can lead to a usable and used product.

When working with users who are developing content, find a balance that promotes author creativity and perspective, while providing sufficient structure to guide development that is consistent with the project’s vision. For instance, some group members found that when working with teachers on authoring, there are benefits in sharing very rough drafts. Wyner gave teachers an early draft that appeared unfinished, which encouraged them to “mess” with the product and add content. Zalles gave his teachers starter lessons (that had undergone expert



review) and set several development parameters, after which the teachers could use those lessons, adapt them, or develop new ones that used the specified geospatial data sets.

We started (our work with the teachers) with a vision of purpose, identifying skills and understandings that are the outcomes, and providing data sets and tools. We took the first shot at developing lessons, knowing they may be more useful for their professional development than for full classroom implementation. We wanted that... We told (the teachers) they could use them as is or develop new lessons that were aligned and based on our parameters. And so they began making their own lessons, incorporating our data and tools.

Zalles

Enlisting end-users as co-developers, project leaders can gain insights on how to balance the need for fidelity with the reality of adaptation when materials are released. While researchers and developers typically wish to test education materials when they are implemented with fidelity, end-users are inclined to use them in whatever way is most feasible and effective for meeting their own instructional aims. Zalles encourages project leaders to accept the reality that end-users will adapt education materials and so design materials that intrinsically address issues of adaptation. For instance, the materials could delineate where there is freedom for adaptation and which are essential features that should be implemented. Trautmann believes that as long as the user understands the critical elements of the model, user adaption during implementation can strengthen use of the materials in a given context.

Teachers are individuals with idiosyncratic situations in their schools... The reality is that when materials go out to a broader world, it is possible that many teachers will not like some aspects of the materials, yet be interested in the objectives. In our project for example, teachers with multiple preps made different adaptation decisions for different student groups and courses they were teaching, such as Earth science for special needs students, environmental science, and AP biology. Hence, they justifiably needed to adapt the materials... Point is, there are different types of schools, teachers, and students, so you must leave room for some adaptation.

Zalles

Learning about user adaptations provides insight into possible revisions of the materials, as well as into areas that could benefit from room for flexibility. Miller suggests that rather than focusing primarily on the degree of fidelity, developers might consider collecting and analyzing user feedback specifically on how and why it was adapted. Often the reasons are good ones. Teachers and district staff can be indispensable in helping developers understand how adaptations are driven by district curricular approaches. Because district and school curricular priorities heavily influence teacher instruction, project leaders should consider embracing adaptation that results in beneficial alignments. Adaptations may also be driven by other on-the-ground realities, ranging from instructional time structures to the availability of classroom technology and resources. Because various contextual features influence how users might modify materials, Brenneman makes a case for looking at adaptation across many contexts in which the developer hopes for adoption.

One of the feedback questions we used was, "Did you modify this and if you did, how, and why?" We got a lot of good stuff back. We incorporated not only the supports they said they used, but also the changes they made in the curriculum.

Miller



Gathering Feedback from User Participants

Group members have found that having ongoing, recurring opportunities for users to provide feedback can help sustain their involvement in the project and maintain the momentum of the work. One strategy for sustaining the relationship is dedicating a key project member to coordinate the regular collection of user feedback. This role, especially if it is filled by someone with experience in schools, can help ensure that the process goes smoothly and that feedback loops stay on schedule. For instance, Pruet's project staff includes a retired teacher who is in schools regularly and is seen as an accessible "face of the project" in the schools.

User participation in projects varies depending on the nature of the project, as can the methods with which their feedback and ideas are solicited and then documented by the project. Participation may range from "full time" development work to intermittent or periodic feedback. Regardless, Thier argues that an irregular, unstructured feedback schedule can limit any project's successful involvement of teachers (pp. 174-175).

In addition to structuring feedback schedules over a set period of time, Thier recommends creating detailed templates for gathering user-input that are designed to facilitate analysis (pp. 170-174). Group members have developed: (1) feedback forms and surveys that include specific questions for the purpose of revising materials and (2) structured protocols for one-on-one or group interviews with users. Several suggest using instruments that are specific to the materials being developed and the users' contexts, or otherwise useful for particular project purposes. For instance, Pruet developed a teacher survey with items focused on the user's implementation, adaptation, and recommended changes. After every field test lesson, Casa and Gavin have had teachers fill out feedback sheets that include a checklist as well as open-ended items. Courey includes well-defined tasks in feedback materials to structure and focus user feedback so it is more useful.

Also, project leaders might consider the benefits of open-ended feedback collected from user groups, such as through debriefing meetings, focus groups, online forums, and development work sessions. Group discussion of implementation provides an opportunity for users to refine and elaborate on their thinking, while allowing project leaders to probe and determine the breadth of opinions. They also help users feel more a part of the larger project effort and reflect on their own implementation within a broader context. Almquist and others have found it effective to structure individual feedback prior to convening for group discussion, as well as walking through materials step-by-step as group. Scopinich used individual questionnaires to inform focus group discussions.

[With focus groups,] I think you get the energy of all the other teachers. The focus groups are just great, because they're bouncing one idea off of another. So instead of just us asking a question and then a teacher thinking about what happened in the classroom,...there's a real conversation going on between the teachers. So it's a much richer experience than just a conversation with a teacher about how it worked.

Wyner

Almquist and Scotchmoor have found that multi-day meetings or institutes provide opportunities for uninterrupted, extended, and highly focused group development work. These



events can bring together end-users who hold different project roles, professional perspectives, and levels of involvement. While resource heavy, they can establish a common vision and project community and move certain types of work forward.

Project leaders may want to use social media—from simple email list serves to Facebook pages—to continue conversations with users. Group members reported that using these electronic tools sustains involvement while providing opportunities to collect feedback on products as they evolve. Several emphasized that ongoing communication through email or social media works better when it builds on previously established relationships and is used for specific communicative purposes.

I think it's probably more satisfying to teachers if they're not just putting their opinions out there into a web survey that they never see the results and never see other teachers' results. So a focus group or an online forum or threaded discussion in which they can see each other's comments may be a better way to go in terms of building a collective knowledge about things rather than just, "Here's what I did."

Trautmann

Users can provide useful feedback through iterative semi-structured document reviews. While projects often have expert reviewers address technical or scientific issues in materials, many should consider the benefits of reviews from those who will use the materials. Scotchmoor's teacher advisory board critiqued every word of the project's website product across several iterations. The feedback improved the efficiency and usefulness for its target users. Casa and Gavin gathered a great deal of feedback through margin comments that their partners added during a page-by-page review prior to and during implementation of the materials, and they followed up on the reviews with user interviews.

Wyner advocates for projects to develop multiple means for teachers to provide feedback, including those discussed above. While different individuals may give richer feedback through different communication modes, various approaches may prove more or less useful depending on the project's specific purposes, stages, and contexts. Most of the contributors to this brief use some combinations of individual and group feedback strategies, as well as strategies that are structured and open-ended.

Project leaders should also consider how student feedback can be used, typically alongside teacher feedback, to dig deeper into gaps in student understandings of key concepts. Pruet and her team, for instance, developed a student interview protocol that includes notes to the interviewer and scripted questions about a specific design challenge. Ault created a game-development club that enabled the project to sustain ongoing relationships with students who provided feedback at all stages of game development. She collected student feedback through conversations, focus groups, and surveys. She also met with teachers every other week to discuss the game and their perspectives on student experiences with it. Like Ault, Scopinich's debriefings with students were useful for drawing feedback on a game's content and playability.



Summary

Project leaders who are developing STEM education materials are interested in having those materials used after their initial grant funding comes to an end. Contributors to this brief believe that K-12 end-users and decision-makers are instrumental for developing materials that will be adopted, implemented with essential fidelity, sustained at classroom and organizational levels, and scaled within and to new organizations. Users can have a valuable role at all stages of the development process, and most projects would benefit from including users in substantive roles, more so than just field-testers. Projects described in this brief have benefited from school, district, and state users serving as Co-PIs, advisory board members, co-developers, implementation managers, data collectors, professional developers, and project emissaries to the broader field.

While it is true that users can help fine-tune materials, this brief serves to encourage and help others who are interested in pursuing deeper purposes for partnering with users. Users can align products to the priorities of potential adopters and correct flawed assumptions undergirding development. They can help design for usability and identify optimal supports for implementation. User feedback is crucial for managing the tension between fidelity and adaptation, and their grounded engagement on this issue can provide a reality check and inform design solutions. When projects partner with end-users throughout the development process, they build their capacity to improve materials and design them for broad long-term use.

References

Thier, H.D. & Daviss, B. (2001). *Developing inquiry-based science materials: A guide for educators*. New York City: Teachers College Press.

