Manchester CREATES 2024-2025
Tech for Teachers Evaluation Report

Teachers in the lab at UNH Manchester. Photo credit: Ary Supan Photography

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Executive Summary

Introduction

Manchester CREATES offers educational programs focused on regenerative medicine and biofabrication (RM&B) to middle and high school teachers and students in the Manchester, New Hampshire region, at no cost to participants. Programming includes the teacher professional development (PD) program Tech for Teachers and student Tech Camp. The goal of these programs is to cultivate interest and expertise in the biosciences through project-based learning (PBL) experiences to address current and future workforce needs in Manchester's growing biotechnology sector, known locally as "ReGen Valley." This formative evaluation report focuses on the first year of Manchester CREATES' teacher PD program, launched with the two-week Tech for Teachers Summer Institute held July 22 through August 2, 2024. The data are from teacher surveys before and after PD, and both surveys and interviews after teachers implemented their RM&B projects in the classroom.

Program Participation

Of the seven teachers in the first cohort, five were veteran teachers with 15 or more years of teaching experience in Manchester School District (MSD) schools. Six taught biology and other science courses at the high school level; the remaining teacher taught 8th grade Life Science. Six heard about Tech for Teachers from someone in their school or district.

Key Findings

- **There was a substantial increase in teachers' average ratings of their RM&B knowledge, ability, interest, and awareness from before to after PD**, for example:
    - Awareness of RM&B partners and resources within NH (+93%)
    - Ability to incorporate hands-on RM&B activities/labs in the classroom (+81%)
    - Ability to get students engaged with RM&B content and methods (+70%)
    - Ability to teach their students about future jobs in RM&B (+67%)

    Additionally, after PD and project implementation, all seven teachers agreed to some extent that they have sufficient knowledge to provide their students with a strong foundation in RM&B concepts. **Teachers also gained confidence in teaching STEM more broadly from pre-PD to after project implementation.**
- **By post-project implementation, all the teachers felt at least *somewhat prepared* to implement PBL in the classroom, an improvement from before PD.** Several teachers described a high level of engagement from their students when working on their RM&B projects. However, they varied in their perceptions of PBL

requiring more or less work to plan and implement compared to a traditional instructional model, and no clear trends emerged regarding changes in specific classroom practices related to PBL. The teachers' comments regarding PBL reinforce that they have a wide range of thoughts on it and experiences with it.

- **All seven teachers in the first cohort successfully implemented their projects in the classroom, bringing RM&B content to 18 classes and 360 students, or about 5% of all middle and high school students in the district.** Teachers also used the skills and equipment gained through the program to benefit other Manchester teachers and students, contributing to an even wider indirect reach. Further, most of the teachers plan to implement RM&B projects in the future, which would expand the program's reach even more.

> "What I didn't expect was how much our students got out of it and how much my other students got out of it as well. Like, some of the lab ideas … I was using with my chemistry kids, I was using with my general biology kids."
>
> Teacher Interview

- **Teachers observed students practice self-directed inquiry-based learning, learn from setbacks, develop problem-solving skills, and gain a sense of responsibility through their RM&B projects.** Several saw students connecting their projects to real-world applications of the skills and technologies they used.

> "They all understand that in response to distress, injury, trauma, that cells can repair, they can grow, and—in some cases—grow back. And I think that was a big part of it, they didn't really understand that in the things that I've done in the past … they know that now."
>
> Teacher Interview

- **During the 2024-2025 school year, more teachers advised students on RM&B secondary education, research, or career pathways and shared resources for teaching RM&B with other teachers than during the previous school years.** They also hosted visits from the UNH STEM-MoBILE and ARMI scientists and educators at their schools and reported them to be effective at engaging their students and raising awareness of local opportunities in the RM&B industry. However, some teachers felt they were not connected enough to regional RM&B higher education and industry representatives to pursue class visits or field trips, or lacked the time.

- **Teachers greatly appreciated the support and physical materials they got from Manchester CREATES during the PD and after PD during the school year**. They identified this aspect of the program as a unique strength compared to other PD in which they had participated and credited this especially to the Project Director's role. Providing the equipment to make the projects a reality was cited as a key support. **Additionally, they highly valued the opportunity the program gave them to connect and collaborate with other MSD teachers within and across their schools.** They also welcomed the chance to connect with RM&B experts from the UNH faculty and local industry. Given all the benefits of these aspects of the program, teachers expressed a desire for them to continue through their first school year after PD and beyond.

> "I appreciate beyond measure the fact that I could dream and then plan and have all the 'stuff' that I needed to do something like this."
>
> Teacher Interview

> "I think the best part of Manchester CREATES was being able to have time to collaborate with other teachers."
>
> Teacher Interview

- **Despite all seven teachers successfully implementing their RM&B projects, all seven also reported a lack of time as at least somewhat of a barrier, including limited planning time and class time for the projects.** Other frequently reported barriers were curriculum pacing and alignment, need for more training/PD, limited equipment and physical space, and difficulty assessing students. Some described additional challenges, such as facing unexpected situations, managing new content and a new type of classroom project, and finding a balance between students' free inquiry and setting parameters for their experiments to improve feasibility.

> "The only difficult thing was anticipating the things that they would want to do."
>
> Teacher Interview

Recommendations for Improvement

- **Additional PD may help to address some of implementation barriers teachers experienced**, which may in turn make RM&B project implementation a less time-intensive endeavor for them. It may also be helpful to provide teachers with more detailed lesson plans and labs that they can easily implement with less preparation. Previous experience implementing the project may also help the next time around.
- **Some teachers see a larger potential role for the program in establishing and sustaining connections with higher education and industry partners**, beyond sharing contact information or making an initial introduction. Consider additional program support during the school year to help teachers make arrangements for guest speakers and field trips and/or additional program structure that would make coordinating these opportunities a lighter lift for teachers.
- **Teachers provided several suggestions that would increase program engagement and support throughout the school year**, including Manchester CREATES staff visiting classrooms more frequently, helping teachers connect with RM&B professionals, and providing additional PD sessions. They also hoped for the opportunity to continue engaging with the program beyond the one school year.

Conclusion

The first year of Manchester CREATES Tech for Teachers demonstrated strong early success in bringing RM&B into Manchester classrooms. The PD prepared teachers to incorporate RM&B into their curricula, increased their confidence in STEM instruction, and strengthened their PBL skills. As a result, hundreds of Manchester students were able to engage in hands-on, inquiry-based RM&B projects. Feedback from the initial cohort of teachers offers guidance to the program for helping to address the challenges they and future participants may face in implementing RM&B projects and connecting with the RM&B ecosystem. With continued investment in teacher PD and community partnerships, Manchester CREATES is well-positioned to expand its impact going forward.

> **"This whole experience has been phenomenal as I have learned so much and have brought so much back to my students in the classroom. I feel that my knowledge about RM&B has allowed me to expose my students to great discoveries happening right in their own city and they thrived in this project. I am so proud of them."**
>
> Teacher Post-Project Survey

Introduction

Manchester CREATES is modeled after its statewide sister program, New Hampshire CREATES the Future: the NH Collaborative for Regenerative Medicine Education and Training for Engineers and Scientists of the Future (NH CREATES). NH CREATES was launched in 2021 in response to regional workforce needs in the field of regenerative medicine and biofabrication (RM&B). It is based at the University of New Hampshire (UNH) at Durham and funded by a National Institutes of Health (NIH) Science Education Partnership Award (#1R25GM137381-01), building on the success of Tech Camp and the Tech for Teachers Institute, two longstanding summer STEM programs at UNH. As described in the program's NIH grant proposal, the "overall goal of NH CREATES is to establish a robust pipeline extending from middle school to higher education for the burgeoning RM&B industry in New Hampshire."

In September of 2022, a coalition led by the City of Manchester was awarded $44 million in federal grants from the U.S. Economic Development Administration as part of the national Build Back Better Regional Challenge. This funding supports the development of a biofabrication cluster in Manchester, already home to the Advanced Regenerative Manufacturing Institute (ARMI) and a growing number of biotech start-ups. As a member of this coalition, UNH received funding to expand its NH CREATES workforce development initiative to the UNH Manchester campus with Manchester CREATES.

Manchester CREATES offers educational programs focused on RM&B to middle and high school students and teachers in the Manchester region at no cost to participants, including as its cornerstones the teacher professional development (PD) program Tech for Teachers and student Tech Camps modeled on NH CREATES. The shared goal of these programs is to cultivate interest and expertise in the biosciences through authentic project-based learning experiences to address current and future workforce needs, with a particular focus on Manchester's unique RM&B industry connections. Manchester CREATES programming launched in the summer of 2024 with a two-week Tech for Teachers PD Summer Institute and two week-long sessions of student Tech Camp, all held at UNH Manchester for participant accessibility and convenience.

Manchester is demographically unique in our state, representing a different economic and sociocultural context for the NH CREATES program model. In recent Census estimates, the percentage of children under age 18 in households with income below the poverty level was 8% for New Hampshire overall and 17% for Manchester. Additionally, 81% of children under age 18 in New Hampshire overall were reported as White alone, not Hispanic or Latino, for their race, compared with 52% of children in Manchester (U.S. Census Bureau, 2023). The Manchester School District (MSD) is the largest and most diverse school district

in New Hampshire; according to its website, it is serving 2,500 English language learner (ELL) students, representing 40% of all English language learner students in the state (MSD, 2024). Therefore, there may be greater challenges to address in order to successfully implement the program model here. Yet Manchester CREATES has the advantage of focusing its efforts within this single city: addressing community needs, gaining school district support, building local collaboration networks, and moving towards a critical mass of teachers ready to prepare local students for RM&B education and career opportunities—many of which are located directly in their city. The evaluation results in this report will help to understand the replicability of the NH CREATES model in this specific setting.

About the Evaluation

This formative evaluation report focuses on the first year of Manchester CREATES' teacher PD program, including the two-week Tech for Teachers PD Summer Institute held from July 22 through August 2, 2024, as well as ongoing support and a classroom visit by program staff during the 2024-2025 school year. Seven teachers participated in the first year of PD.

During the Summer Institute, teachers developed their own RM&B project-based learning (PBL) projects to implement in the classroom, applying their knowledge of what works best in the "real world" of their school settings. Manchester CREATES PD instructors modeled PBL principles while facilitating the teachers' project development, further strengthening teacher engagement in PBL. Teachers also had an opportunity to present their projects to the students participating in Tech Camp to solicit constructive feedback from an age-appropriate audience. At the end of the Summer Institute, the program gave teachers a cash stipend as well as equipment and supplies for their RM&B classroom projects. A second stipend was distributed later in the year upon program completion.[1]

Evaluation data sources include the following, all with 100% response rates:

- Tech for Teachers Summer Institute pre-PD and post-PD surveys, administered via Qualtrics on the first and last day of PD while on-site.
- A post-project implementation survey administered via Qualtrics after each teacher completed their RM&B classroom projects with students, thus the timing varied.
- Post-project virtual interviews conducted to gather more open and in-depth information about teachers' experiences implementing their RM&B classroom projects and reflections on the full program year. Interview recordings were transcribed using Temi automated transcription and lightly edited for clarity.

[1] Including participation in the evaluation activities that contributed to this report.

The teacher surveys were based on surveys developed for NH CREATES in a collaboration led by Rockman et al Cooperative, NH CREATES' external evaluator, with minor modifications. Quantitative survey data were analyzed *descriptively* (describing the results) as well as *longitudinally* (exploring change over time) using IBM Statistics SPSS (Version 31) and Microsoft Excel. However, the small sample size (n=7) prohibited meaningful statistical testing. Qualitative interview and survey data were coded into themes using NVivo 15 to facilitate summarizing and communicating the results. Our *thematic coding* approach was both *deductive* (developed to respond to our evaluation needs) and *inductive* (organically emerging from participants' accounts of their own experiences). Themes were revised throughout the process as we learned more about the content of the qualitative dataset.

We recently obtained permission to conduct a survey with students of the first and second cohorts of MSD teachers after their RM&B project implementation in the 2025-26 school year,[2] which will add a new and important perspective to our evaluation going forward.

The logic model in Appendix A outlines the anticipated short-, mid-, and long-term outcomes of Manchester CREATES this evaluation intends to address. At this stage of the program the focus is on the short- and mid-term outcomes.

About the Participants

Of the seven teachers in the first cohort, five were veteran teachers with 15 or more years of teaching experience in MSD schools. Of the remaining two, one had one to three years of teaching experience and the other had four to ten years, all in MSD schools. Six of the seven teachers taught at the high school level; all six of them taught 10th grade classes, and four also taught classes at other grade levels across the high school range of 9th to 12th grade. All six high school teachers taught Biology classes (including AP Biology), and four taught other subjects as well including Anatomy and Physiology, Essential Science, Physical Science, and Physics. The remaining teacher taught 8th grade Life Science.

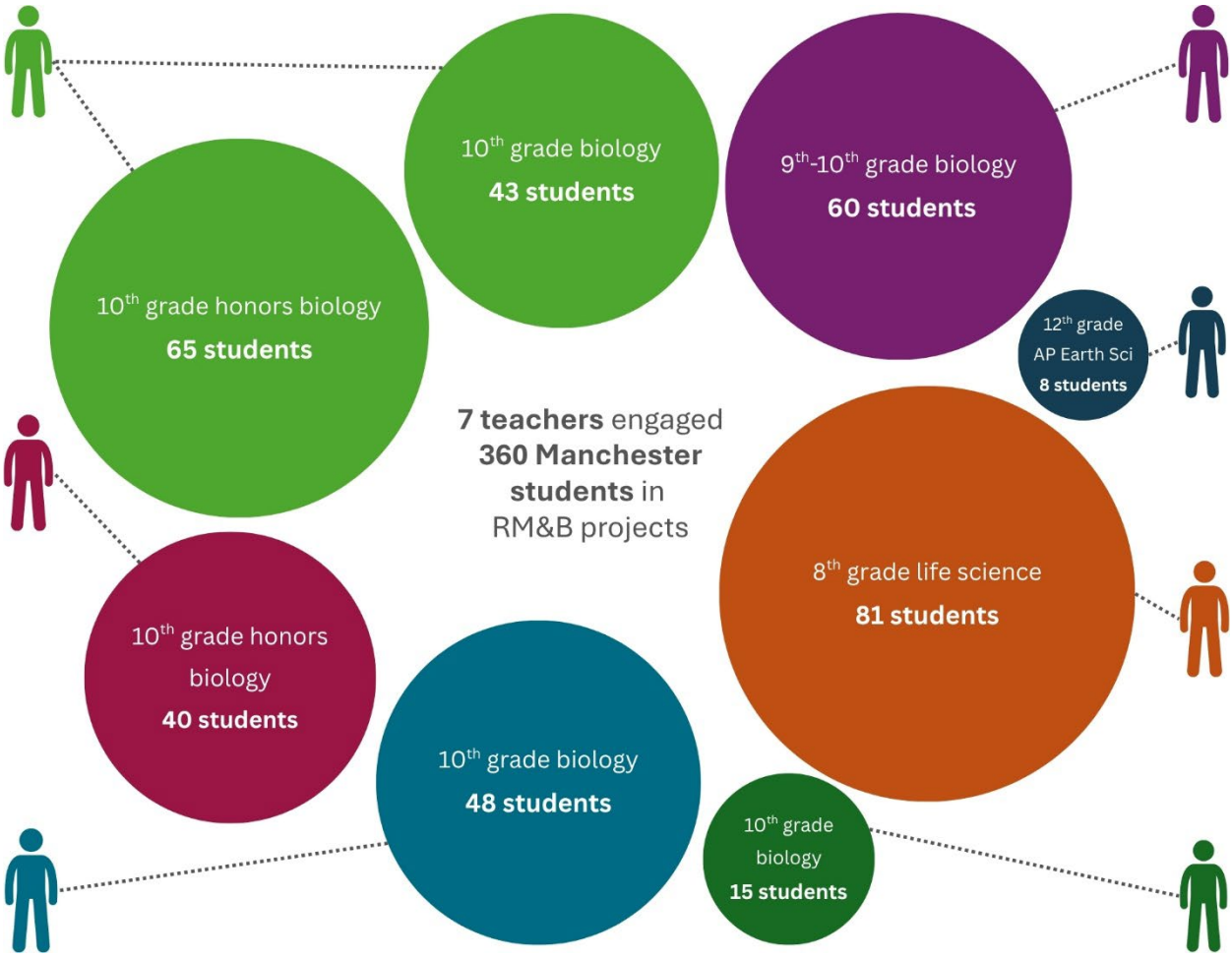
Six of the seven teachers heard about Manchester Tech for Teachers from someone in their school, via district email, or from MSD representatives (the Curriculum Director or Assistant Superintendent of Teaching and Learning). The remaining teacher heard about it from promotional materials through the Manchester CREATES website and print materials.

[2] Permission from MSD and the University of New Hampshire Institutional Review Board. Student survey participation will require parent/guardian opt-in (for minors) and student assent.

RM&B Project Implementation and Reach

Wide Reach of RM&B Projects

All **seven teachers** implemented their Manchester CREATES RM&B projects in a total of **18 classes** with **360 students** – meaning approximately **5% of MSD middle and high school students got to participate in a Manchester CREATES RM&B project.**



During the 2024-25 school year, all seven MSD teachers implemented their Manchester CREATES RM&B projects in a total of 18 classes with 360 students. Although the teacher cohort size may be considered somewhat small, the program reached approximately 5% of MSD middle and high school students in its first year alone.[3] Asked if they plan to implement their RM&B projects again next year, five teachers said *yes* and two said *maybe*.

[3] Based on 2024-2025 Public School Enrollments by Grade at https://my.doe.nh.gov/iPlatform.

Additionally, seven more MSD teachers participated in the 2025 Tech for Teachers cohort. Therefore, we anticipate an even greater proportion of MSD students to be reached by the program in the 2025-26 school year.

About the RM&B Projects

Five of the seven teachers did the planaria project. Most of these projects involved students exploring variables that supported or impeded planaria regeneration.

One teacher did the E. coli project, in which students grew E. coli bacteria under UV light.

One teacher did multiple projects that included experiments with decellularizing spinach, plant regeneration, and ghost organs.

Preparation and Support for RM&B

In the post-PD survey, teachers rated their level of RM&B content knowledge, ability, interest, and awareness before and after PD on a five-point scale of *none* to *a lot*. This method is known as *retrospective pre-post* because it asks survey participants to look back and reflect on their own gains. It was used here primarily because there was no expectation of RM&B familiarity coming into PD. **All items showed substantial increases in average ratings from before to after PD.** The greatest increases were for:

- Awareness of RM&B partners and resources within NH (+93%)
- Ability to incorporate hands-on activities/labs about RM&B in the classroom (+81%)
- Ability to get students engaged with RM&B content and methods (+70%)
- Ability to teach their students about future jobs in RM&B (+67%)

We repeated the RM&B content knowledge, ability, interest, and awareness items in the post-project implementation survey. A pattern emerged in which for about half the items, ratings increased a bit further between post-PD and post-project implementation (Figure 1), and for the other half, they decreased a bit (Figure 2). It is possible that some aspects of their RM&B experience were strengthened by classroom implementation and ongoing PD and others diminished with time or were challenged by classroom implementation. Or it may be due to the use of the retrospective pre-post method in the post-PD survey and then a traditional post-test method at post-project implementation. These trends may become clearer and/or better explained as we gather more data over the years of the program. In

any case, all ratings were still substantially higher at post-implementation than at pre-PD; the increases resulting from PD largely held.

Additionally, at both post-PD and post-project implementation, **six of the seven teachers *agreed* or *strongly agreed* that they have sufficient knowledge to provide their students with a strong foundation in RM&B concepts**, and the last *somewhat agreed*. In post-project interviews, some teachers also reported that they **learned specific content knowledge** about regenerative medicine and planaria.

Qualitative data from open-ended questions in the post-PD survey provide additional examples of the ways in which the PD impacted teachers' awareness of RM&B and how it could be incorporated into their classrooms. One reflected, "there are many models that are available to study for regenerative medicine that are being studied currently that can be applied to the classroom." Several teachers noted they became **more aware of opportunities and research happening in Manchester**—one said that it is "at our fingertips." Another remarked, "the research going on in Manchester is amazing and offers so many opportunities for everyone in this area." A couple of teachers also mentioned that they **learned about RM&B's applications beyond the teaching context**. One said, "There are so many technologies out there that I had no idea even existed."

All seven teachers reported that building- and district-level administrators, community partners, and students were at least *somewhat supportive* of incorporating RM&B into their curricula, with most reporting *very supportive*. Most, but not all, also reported that the school board was supportive. The teachers seemed less clear about how supportive MSD parents and guardians are of incorporating RM&B, with several skipping the survey item and the rest varying in their responses.

Teachers' Understanding of RM&B

In the post-PD survey, teachers were asked to describe how they would explain RM&B to a teacher who had never heard of it. Responses focused on how RM&B works, the industry's presence in Manchester, and its applications and potential in healthcare innovation.

"Imagine being able to create something that would allow us to replace tissues or organs that would match a person and would not be rejected. Regenerative medicine is what would make this possible."

"Using biotechnology to grow cells and tissues for experimentation and human tissue replacement."

"Regenerative medicine is an up-and-coming field in Manchester."

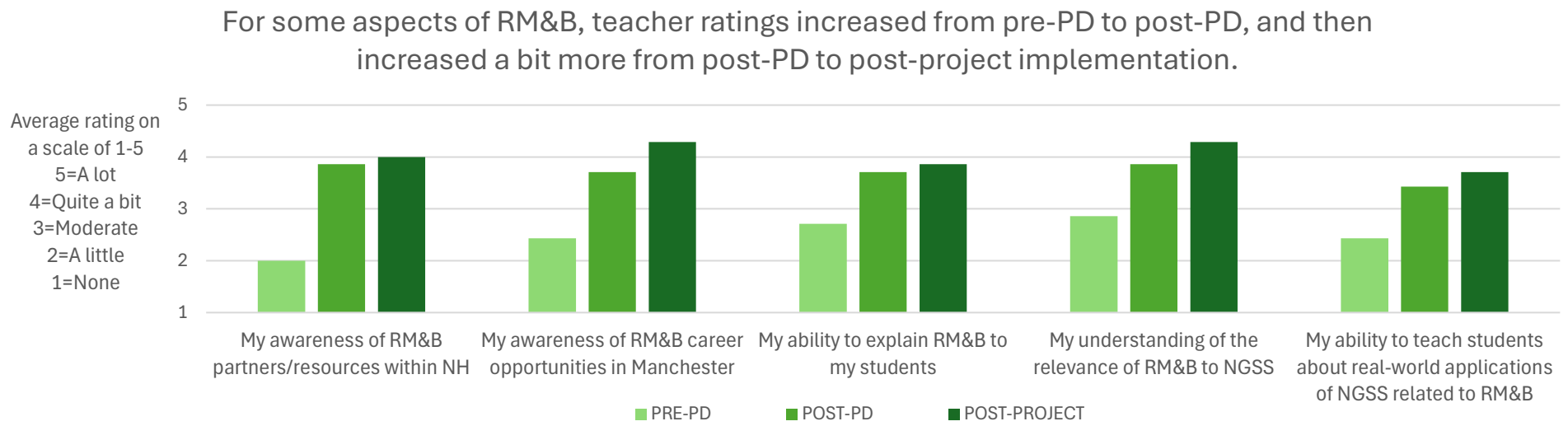


Figure 1. Average teacher ratings of their level of RM&B knowledge, ability, interest, and awareness before PD, after PD, and after RM&B project implementation (n=7).

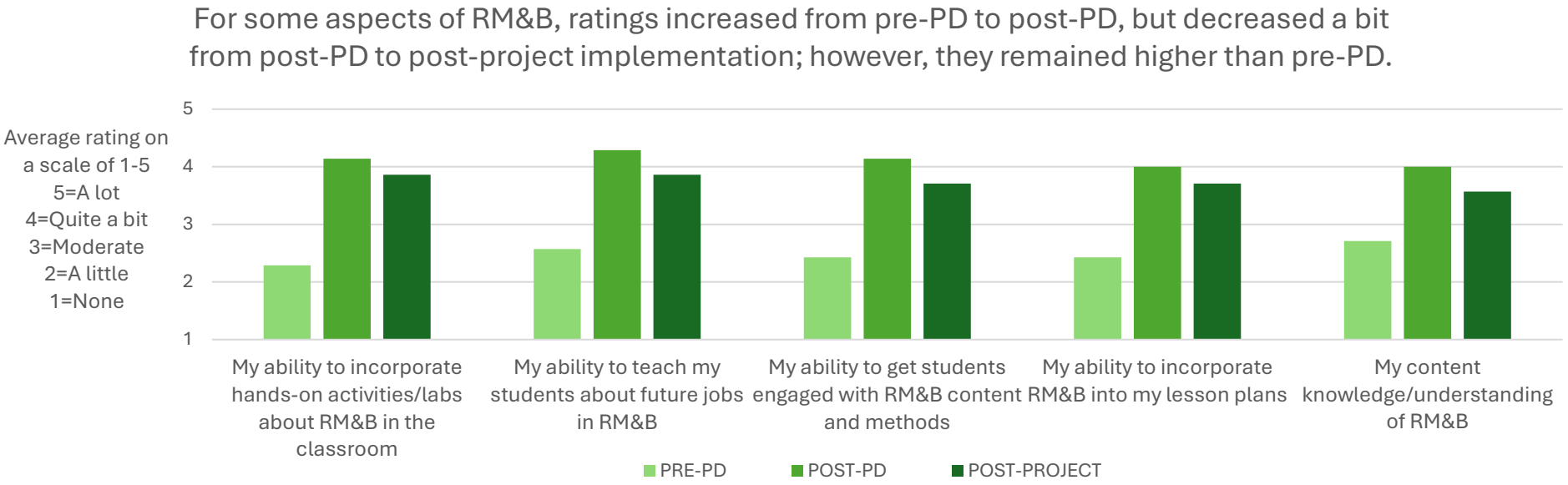


Figure 2. Average teacher ratings of their level of RM&B knowledge, ability, interest, and awareness before PD, after PD, and after RM&B project implementation (n=7).

Barriers to RM&B Project Implementation

In the post-project survey, at least half of the teachers reported lack of time, curriculum pacing and alignment, need for more training/PD, limited equipment and physical space, and difficulty assessing students as at least *somewhat of a barrier* to successful RM&B project implementation. All teachers reported lack of time as a barrier, about half as a *moderate* or *major barrier*. Two specified this further as limited planning time and class time. Most reported competing district and state priorities as *not at all a barrier*, although one or two considered them a *moderate* or *major barrier* (Figure 3).

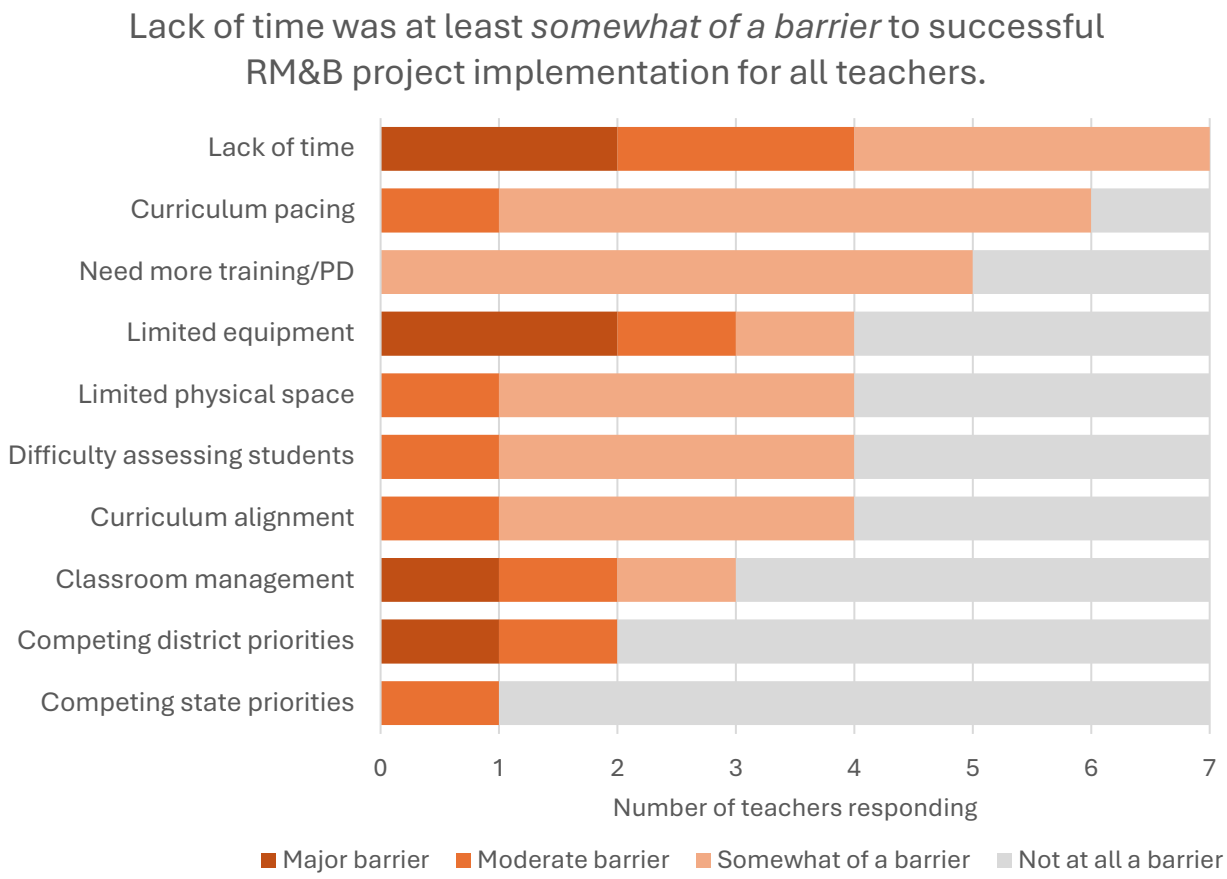


Figure 3. Teacher reports of barriers to successful RM&B project implementation on a scale of not at all a barrier *to* major barrier *(n=7) in descending order of total number of teachers reporting at least* somewhat of a barrier.

While the teachers were generally happy with how their projects went, in their interviews and survey comments they discussed a few challenges that impacted their ability to implement their RM&B projects according to plan.

For some, these challenges related to **unexpected situations** that arose, both related to the project itself (e.g., planaria dying) and outside factors (e.g., a teacher being out on some project days).

> **"I was hoping we wouldn't have a tragedy and have the little critters die, but we did have some of that happen."**
>
> Teacher Interview

Teachers explained that **being new to teaching in general, new to PBL, or new to their subject area** could present a barrier to successful implementation. One of the newer teachers shared that they had trouble with classroom management and figuring out how long the project would take. Another said that it was difficult to keep the students engaged after the first week of the project. A third teacher pointed out that although they had PBL experience, they imagined that "if you were new to implementing a full project like that, I think it might've been a little bit like, 'oh no, what am I [doing?] … What's happening?'"

> **"The only difficult thing was anticipating the things that they would want to do."**
>
> Teacher Interview

The **open-endedness of PBL** made preparation difficult for one teacher: because they wanted to say "yes" to any variable their students wished to explore, they had to try to anticipate the students' experiments so they could prepare the materials.

Two teachers realized their **students needed more "background information"** to successfully work on the RM&B projects, both in terms of content knowledge (e.g., learning what planaria are) and in terms of scientific principles (e.g., the scientific method or control variables vs. dependent variables).

> **"You always hope that [students] come in with an understanding of the scientific method and with an understanding of what controls are and what the variables are, and things like that. But [my students] had to really get a better understanding of those [at the start of the project.]"**
>
> Teacher Interview

As shown in the chart above, **lack of time was** a challenge for every teacher. One noted that their school's daily class schedule also made lab set-up and clean-up difficult: "We get 53 minutes or something like that … for a class. And it's not a lot of time." They continued, "to be able to do it properly takes a little bit more time."

In addition to reflecting on the challenges they experienced, the teachers shared a variety of effective practices and tips for other teachers that supported successful project implementation, which are included in Appendix B.

RM&B Ecosystem Activities

The *RM&B ecosystem* refers to a mostly informal network of regional higher education, research, industry, K-12 school, and community members who promote and engage in RM&B activities. In the post-PD survey, teachers selected activities related to the RM&B ecosystem they had engaged in during previous school years from a checklist and optionally provided a brief description of each. In the post-project implementation survey, they selected the activities they had engaged in so far during the 2024-2025 school year.[4]

During the 2024-2025 school year, most of the teachers selected at least two ecosystem-related activities from the checklist. The most frequently selected activities in the 2024-2025 school year were advising students on RM&B secondary education, research or career pathways; connecting students with RM&B summer programs; and sharing resources for teaching RM&B with other teachers (Table 1).[5] There was limited engagement with students' families related to RM&B, participation in conferences and workshops related to RM&B, and networking with others interested in RM&B beyond the district.

UNH Manchester in the Manchester Millyards, home of the ReGen Valley Tech Hub. Photo credit: UNH Manchester website

[4] The varied timing of the post-project survey throughout fall and spring means this may be an undercount of their ecosystem-related activities for the full school year.

[5] In the post-PD survey, this survey item asked about sharing "best practices for RM&B." The item was changed to "resources for teaching RM&B" at post-project implementation.

Table 1. RM&B ecosystem related activities in the 2023-24 and partial 2024-25 school year (n=7).

Activity	# of Teachers Selecting		Examples
	Previous Years	Partial 2024-25 SY	
Advised students on RM&B secondary education, research, or career pathways	1	4	N/A
Shared best practices/resources for teaching RM&B with other teachers	1	4	N/A
Connected students with RM&B summer programs (post-project only)		4	UNH Tech Camp
Accessed information or resources for bringing RM&B topics into the classroom	4	3	ARMI BioTrek, UNH STEM-Mobile, SEE Science Center, ngss.org
Hosted classroom guest speaker(s) on RM&B secondary education, research, or career pathways	2	3	ARMI scientists and educators, UNH STEM-Mobile
Participated in RM&B PD activities other than Manchester CREATES	1	2	ARMI BioTrek
Took class field trips to learn about RM&B secondary education, research, or career pathways	2	1	ARMI, UNH Manchester, SNHU
Informed students' families about RM&B secondary education, research, or career pathways	1	1	N/A
Attended a conference or workshop related to RM&B	1	1	ARMI Biotrek, Amgen
Collaborated with others to promote RM&B education	1	1	ARMI BioTrek and Manchester CREATES educators, other MSD teachers
Connected students with RM&B mentors (post-project only)		1	N/A
Incorporated RM&B into after-school or summer program activities (post-project only)		1	N/A
Networked with others interested in RM&B education outside my organization (post-project only)		1	N/A
TOTAL ACTIVITY SELECTIONS	**14**	**28**	

In their post-project survey comments and interview, several teachers recounted how they connected their students with the RM&B industry or higher education as part of Manchester CREATES. Four teachers had the UNH STEM-MoBILE visit their schools, which they described as "awesome," "beneficial," and "fantastic." One teacher remembered that their students "lit up with that experience" and were "begging for more." In their interview, this teacher explained that it was helpful to have an "expert" come in to share information with their students:

> "It's kind of like … having a parent tell you, 'this is the way it is.' It's like, 'yeah right.' And then somebody else tells 'em that and it's like, 'oh yeah that's the expert.' Like, what would *I* know as their teacher? So it's nice to have somebody *official* come in and talk to them."

Another enthused, "having [the STEM-MoBILE] come in, that interest was phenomenal. The kids loved it. It was a great experience."

UNH STEM-MoBILE. Photo credit: UNH Manchester website

Two teachers found other ways to **emphasize the RM&B presence in Manchester** for their students. One had Gabrielle (Gabby) Rodriguez, ARMI Education & Workforce Development Manager, and Alanis (Ali) Vicente, ARMI Education & Workforce Development Specialist, come to their class as **guest speakers** to give a presentation about "the different opportunities that are going on in 'ReGen Valley,' just so the kids are aware that this stuff is happening right under their nose." Another teacher reported that they were in the process of planning a field trip for their students to visit UNH Manchester so they can "see what's going on right there." One teacher noted that they had **connected with ARMI** and would be piloting their BioTrek program later during the school year.

Local Connections

A few teachers' post-project implementation surveys highlighted the unique local RM&B connections and opportunities in Manchester. One teacher expressed that "teaching real science that especially has a connection in Manchester" was a benefit of the program. One appreciated that the program allowed students "to connect to things happening in real time in our city," and another welcomed introductions "to people working right in Manchester" and "resources to reach out for our classes."

> **"Students are able to learn content in a way that connects to current advancements in the biological sciences in general and specifically in Manchester. Students find a lot of the RM&B fascinating and cool which helps engage students."**
>
> **"Incorporating RM&B in my classes has exposed the students to up-to-date research and development. My students were able to successfully [decellularize] spinach like scientists at WPI are doing."**

However, teachers also recalled **difficulty in making connections with RM&B professionals and UNH faculty**. For some that wanted to bring in guest speakers from the field or bring their students on a field trip to ARMI, these plans did not come to fruition.

> **"If I were to do it again, I would really try to do something where I could maybe even, like, just bring somebody in for a day. … That's probably the biggest thing I would try to change, is just get an expert to come in."**
>
> Teacher Interview

Teachers described a few specific barriers that got in the way of building stronger RM&B industry connections:

- Forgetting information about the industry professionals between the end of PD and the RM&B project during the school year: "When you're there over the summer and you talk and then they go away, they're out of sight, out of mind in many ways."

- Not feeling connected enough to the faculty members they met during PD to contact them independently. According to one teacher, Shannon[6] suggested people for them to contact, but they would have appreciated more facilitation in establishing the connections. Another teacher explained that they reached out to someone in higher education after Shannon made an initial connection, but they never received a response.
- Running out of time: "I just think that sometimes the year gets away from you."

> **"Some things fell to the wayside and I wish I was able to bring in more industry people to the classroom."**
>
> Teacher Interview

Strengthening RM&B Connections: Suggestions from Teachers

In addition to discussing their challenges, teachers also shared a few ideas that would help future participants make stronger connections to RM&B experts:

- Host an "informal mixer" midway through the school year to re-connect with the industry professionals and UNH faculty from Tech for Teachers. This would allow teachers to ask questions they would not have thought of during the PD: "Now we've implemented things, now we know what we might need a little bit better … I might have a question that I didn't know I had until I got in it."
- Identify prospective guest speakers who "would be comfortable speaking to middle or high school students," because teachers sometimes "get protective" of their students and do not want a guest speaker who may create a negative RM&B experience for their students.
- While teachers appreciated that Shannon would name people they could contact, a couple of teachers suggested that the Manchester CREATES team could do more to facilitate outreach and connection between teachers and RM&B professionals so teachers do not have to cold call contacts or spend a lot of time trying to get a response. "I tried … to reach out to someone at a different university. And Shannon managed to broker that and finally get a response. But then when I asked him a question, I never got a response again."

[6] Shannon McCracken-Barber, Manchester CREATES Project Director and PD lead.

STEM Teaching Confidence

Teachers rated their agreement with 18 statements about their confidence teaching STEM at pre-PD, post-PD, and post-project implementation on a six-point scale of 1 *strongly disagree* to 6 *strongly agree*. **From pre-PD to post-project implementation, the average level of agreement moved in the desired direction for 17 of the 18 statements.**[7] (For five negatively worded statements, *lower* average agreement was the desired direction.) The greatest changes in average agreement were:

- I find it difficult to explain to students why and how specific research methods are applied to address specific STEM questions and/or problems (-35%)
- I need more knowledge about STEM concepts to be an effective STEM teacher (-29%)
- I can answer most STEM questions that my students ask (+24%)
- The STEM concepts that I teach my students reflect the latest STEM advances (+21%)

The examples in Figures 4 through 6 below show the number of teachers *agreeing* or *strongly agreeing* with the statements at pre-PD, post-PD, and post-implementation. They indicate increased confidence in effectively teaching up-to-date, real-world STEM concepts and responding to students' STEM questions (Figure 4), explaining STEM investigation methods and laboratory procedures (Figure 5), and spurring their students' interest in and progress toward STEM education and careers (Figure 6). **The examples of negatively worded statements, which show the number of teachers *disagreeing* or *strongly disagreeing*, are displayed separately in Figure 7 to avoid confusion; to clarify, these too indicate improvement in STEM teaching confidence.**

As with the RM&B preparation items, sometimes there was continued improvement in teachers' STEM teaching confidence from post-PD through project implementation, and sometimes the post-PD improvement held steady. Unlike with RM&B preparation, however, no items showed a decline between post-PD and post-project implementation. The retrospective pre-post method was not used for the STEM teaching confidence items, which may explain this difference in their pattern of results.

[7] The exception was 'I am confident in my ability to help students understand the relevance of their investigations to real-world issues in problems' which started with a high average level of agreement at pre-PD (5.14) and decreased slightly (to 5.00) by post-project implementation.

Other notable findings in this area include:

- At post-PD and post-project implementation, all seven teachers *agreed* or *strongly agreed* with the statements 'I am able to explain the STEM concepts that underlie a given laboratory procedure or protocol,' and 'when a student asks for advice on how to investigate STEM issues, I am able to suggest appropriate methodological approaches and procedures.'
- Although it increased with time, there was lower agreement with the statement 'I am able to stimulate student interest in, and excitement over, STEM careers,' compared with the other positively worded statements.
- Disagreement with the statement 'I need more knowledge about STEM concepts to be an effective science teacher' was also comparatively low despite moving in the desired direction over time.

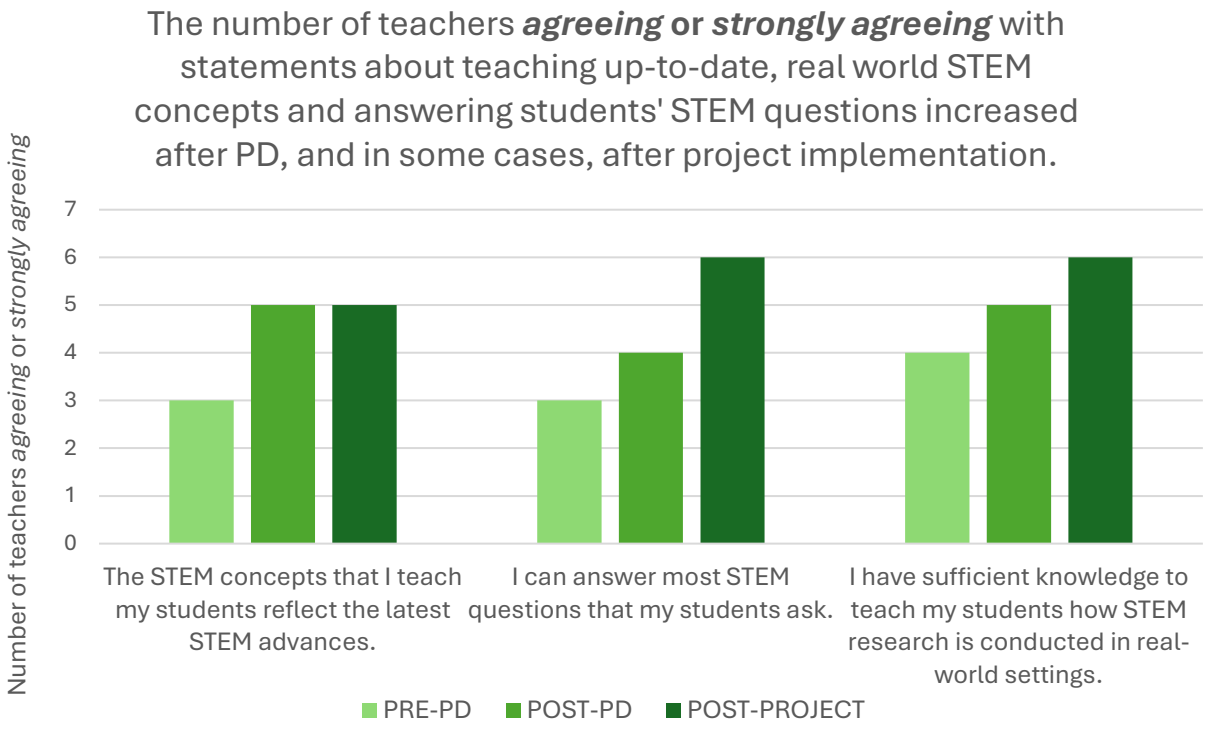


Figure 4. Number of teachers agreeing *or* strongly agreeing *with statements about teaching up-to-date, real-world STEM concepts and answering students' STEM questions before PD, after PD, and after RM&B project implementation (n=7).*

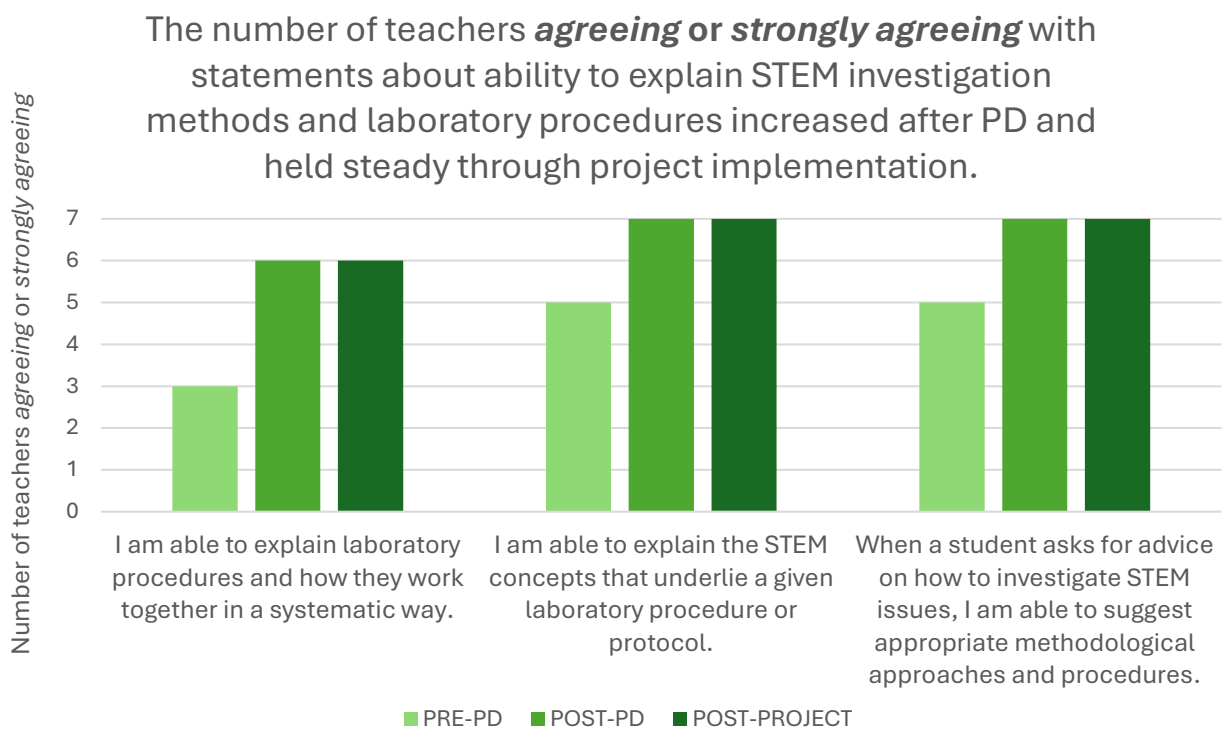


Figure 5. Number of teachers agreeing *or* strongly agreeing *with statements about ability to explain STEM investigation methods and laboratory procedures before PD, after PD, and after RM&B project implementation (n=7).*

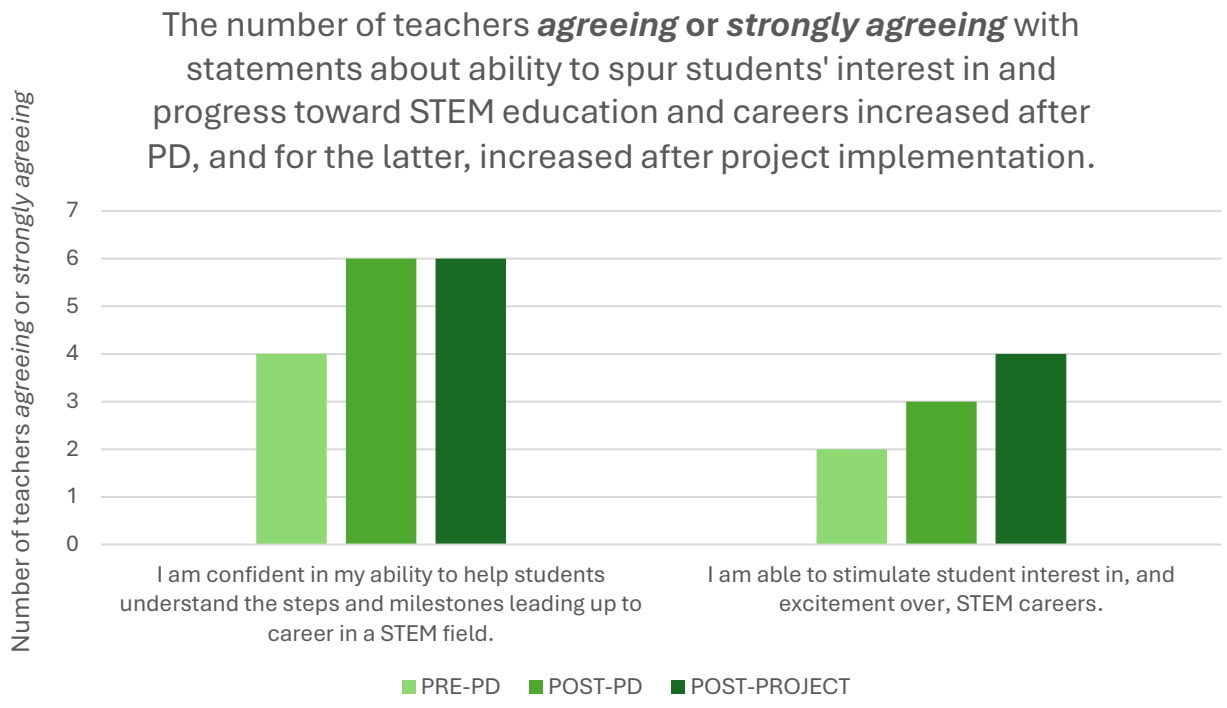


Figure 6. Number of teachers agreeing *or* strongly agreeing *with statements about ability to spur students' interest in and progress toward STEM education and careers before PD, after PD, and after RM&B project implementation (n=7).*

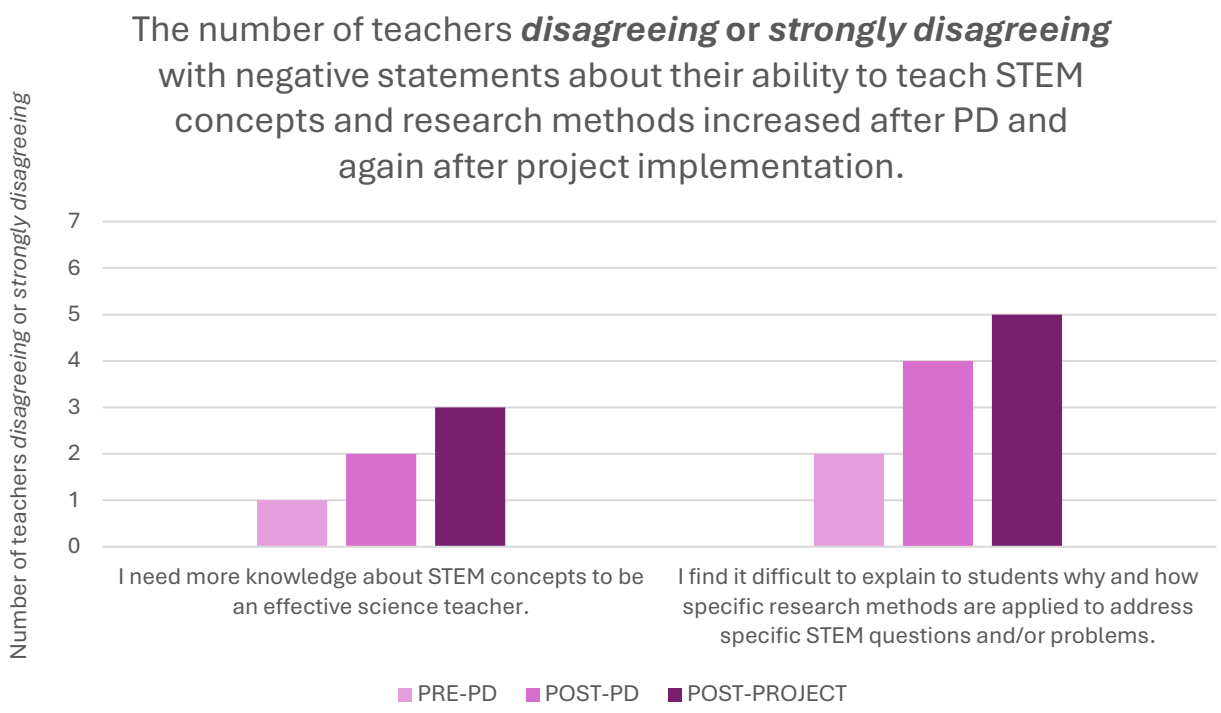


Figure 7. Number of teachers disagreeing *or* strongly disagreeing *with negative statements about ability to teach STEM concepts and research methods before PD, after PD, and after RM&B project implementation (n=7).*

PBL Practices and Attitudes

In the pre-PD survey, six of the seven teachers reported they had attended at least one PBL workshop, conference, or training during the previous two years. Five had prior experience implementing PBL, ranging from less than one year to more than 15 years of experience. However, only three reported that they felt *prepared* or *very prepared* to implement PBL in the classroom. The remaining four felt *somewhat prepared* or *not at all prepared*.

By the post-project implementation survey, all teachers felt at least *somewhat prepared* to implement PBL in the classroom. The self-assessed level of preparedness increased for three of the teachers; one went from *not at all prepared* to *very prepared* (Figure 8).

> **"I learned how to develop a PBL enough that I would have confidence in executing [it] myself."**
>
> **Teacher Post-PD Survey**

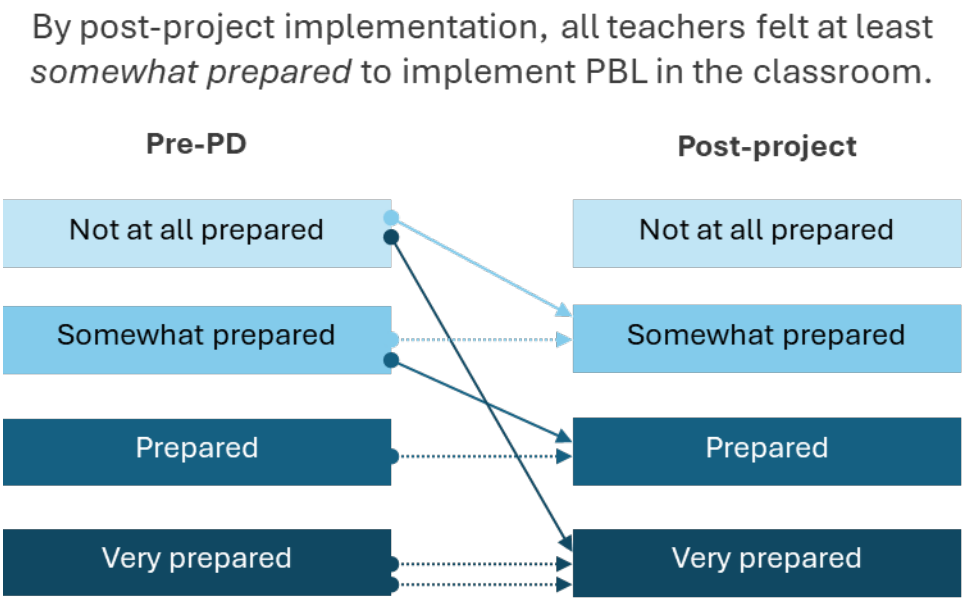


Figure 8. Change in teachers' self-assessed preparedness to implement PBL in the classroom from before PD to after RM&B project implementation (n=7).

In post-project interviews, most teachers said that they are **interested in doing more PBL in the future** and that the program has helped them learn strategies to **integrate PBL into their teaching**. Several expressed openness to doing their projects again next year and continuing to improve them using what they learned this year. One explained that PBL principles have "woven into my entire year and curriculum" and their experience "infiltrates every level of assignments I do and mindset." Another thought they will have "a little better leg up" if they do their project again next year.

> **"Using PBL in an effective way is something that I would like to do more of, so I appreciate this experience for that opportunity."**
>
> Teacher Interview

> **"Sometimes we get stuck in ruts.... I think the aspect of looking at biology through a lens of something different, in a different way, through electricity or different types of modeling or other things like that allows me to be refreshed and not stagnate in my own knowledge. And I think that's pretty priceless."**
>
> Teacher Interview

Two teachers reflected that the projects helped them "give up control a little bit" and become **more comfortable with helping students learn through experimenting** rather than "trying to get them to achieve a specific result." One explained that trying to support any of the directions students might take in their experiments gave them "more

confidence" to do an open-ended project or experiment with their classes, even if this is typically outside of their comfort zone as a teacher.

In the pre-PD and post-project implementation surveys, we asked teachers about their PBL practices in the classroom. No clear patterns emerged in the results. There was some increase in teachers' use of portfolios for PBL assessment and having students create an original product or performance to express their ideas.

At post-project implementation, six of the seven teachers rated PBL *somewhat* (5 teachers) or *much more effective* (1 teacher) as a pedagogical approach compared to a traditional instructional model; when asked about the comparative amount of work to plan and implement PBL, their responses varied (Figure 9). None reported that PBL was a *much less* or *somewhat less effective* pedagogical approach, or that it was *much less work* to plan and implement. Three reported using PBL in the classroom beyond their RM&B projects.

Teachers also compared how PBL influences student reception of class material compared to a traditional instructional model in their experience on a five-point scale of *strong negative influence* to *strong positive influence*. Most found it to have at least *some positive influence* on students' class participation, enthusiasm for course material, motivation, confidence, and achievement. Almost half found it to have a *strong positive influence* on student enthusiasm for the course material (Figure 10). None found PBL to have a negative influence of any strength on any aspect of student reception.

Most teachers found PBL more effective than a traditional instructional model but varied on the comparative amount of work to plan/implement.

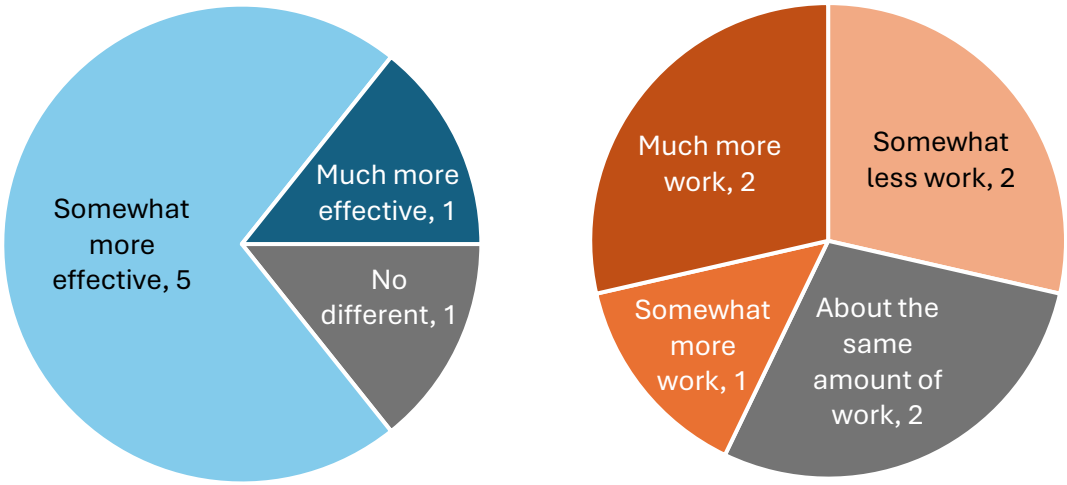


Figure 9. Teachers' comparisons of PBL to a traditional instruction model in the level of effectiveness and amount of work to plan and implement after RM&B project implementation (n=7).

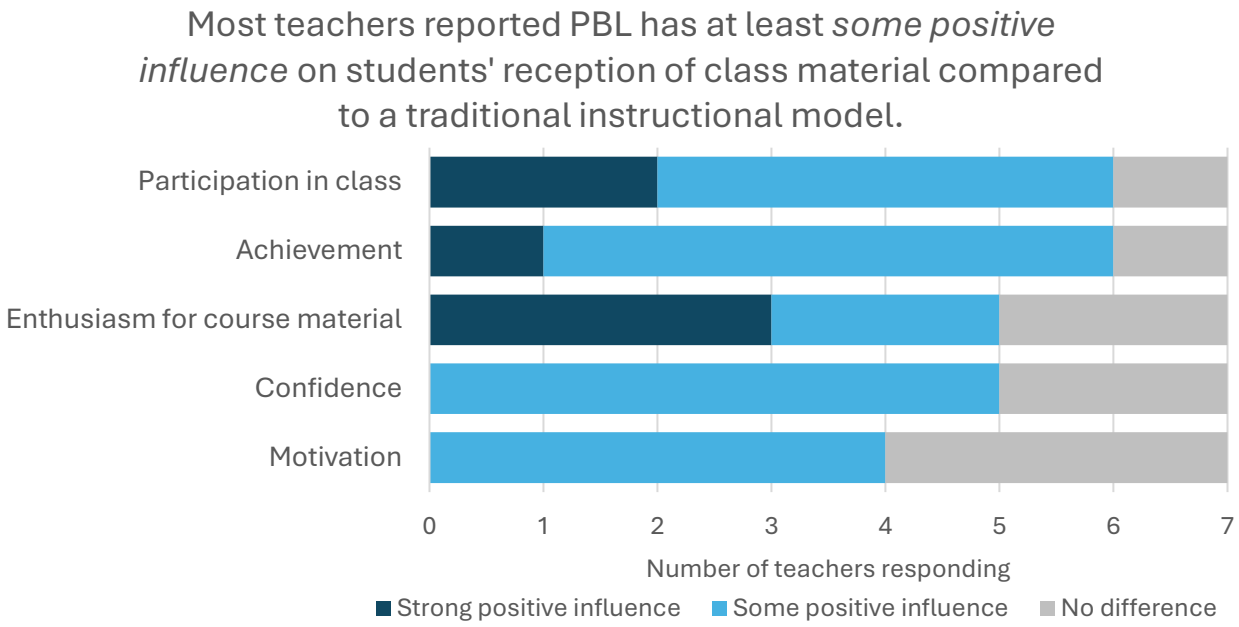


Figure 10. Teachers' comparisons of PBL's influence on student responses compared to a traditional instructional model after RM&B project implementation (n=7) in descending order of at least some positive influence.

Three teachers submitted optional comments on PBL in the post-project implementation survey illustrating the range of their experiences with the approach:

> **"I am used to having increased success by providing more structure to assignments. It is difficult to motivate them to be more self-driven."**
>
> Teacher Post-Project Survey

> **"PBL is the best way, I believe, that science instruction should be delivered … learning to solve real world problems through PBL provides students with great opportunities to learn science and explore great investigations. I love PBL and would never go back to the old school way I used to teach."**
>
> Teacher Post-Project Survey

> **"I would love to implement PBL, but I do not feel equipped to implement it fully. I feel like it is difficult for me given the time restraints and the lack of a coherent district curriculum to fully plan and implement a PBL project. This year I worked on incorporating components of PBL, but with a lot less fidelity than I would wish to."**
>
> Teacher Post-Project Survey

In post-project interviews, several teachers reflected on how fun it was to see their **students' engagement and excitement** about their hands-on PBL experiences with RM&B. They described how much their students cared about their planaria or plants and their students' investment in the projects. One enjoyed seeing "the different ideas that [my students] came up with" for their experiments and the "trial and error" of the students' projects. Several survey responses also highlighted the effectiveness of hands-on learning in engaging students; one teacher wrote, "focusing on hands-on projects increased relevance and engagement." Another appreciated that "every kid got something, some piece out of it."

> **"Some kids named [their planaria]. It was so cute. … And then like, so when they did their presentation, they were like, 'Oh, Peter died. But then we got Peter Two.'"**
>
> Teacher Interview

> **"They would come in and check on their plants like they were little babies. They were so excited when they would grow. And then they would talk to the plants—which was hysterical—when they weren't growing, to encourage them, which I thought was so fun."**
>
> Teacher Interview

District-Level Support for PBL

Six of the seven teachers reported that MSD is very supportive of the PBL approach. In interviews, some relayed that district-level staff, such as the Curriculum Director, visited their classrooms while they were working on their project. One noted that this has "generated some buzz" and given teachers the opportunity to express their own support for PBL and the program. One teacher also gave a presentation to the school board about "technology in the classroom and how that's improved" and how students have "been able to do [things] that they wouldn't have been able to do in the past."

Program Highlights

> **"This whole experience has been phenomenal as I have learned so much and have brought so much back to my students in the classroom. I feel that my knowledge about RM&B has allowed me to expose my students to great discoveries happening right in their own city and they thrived in this project. I am so proud of them."**
>
> Teacher Post-Project Survey

> **"I only have positive things to say about it."**
>
> Teacher Interview

Program Impact

In addition to the impact on their instructional practices and awareness of RM&B, teachers described a wide variety of ways in which they observed Manchester CREATES' impact on their students' STEM learning and connections to the RM&B industry. Notably, many teachers also revealed how the program's reach extended beyond the students and teachers directly involved in the program; several described how they applied their new skills with students in classes that did not do RM&B projects and shared learnings with teachers in other subject areas and schools.

> **"The kids, for the most part—I would say probably 95%—were really engaged in it, more so than other activities."**
>
> Teacher Interview

Impact on students' STEM learning

In interviews, teachers recounted how their students learned problem-solving, engaged in inquiry-based learning, developed a sense of responsibility and self-directedness, and made connections to real-life issues through their projects. One teacher conveyed that due to the high level of engagement in the RM&B project, some of their students expressed excitement to continue doing similar project-based learning in the future: "A lot of them actually said, 'I can't wait to have you again for AP bio, because I know that we do cell signaling because they're doing projects on it right now.'"

Another described how excited their students were about the plants they worked with, explaining that "they would come in and check on their plants like they were little babies" and that students who previously hadn't cared about plants "find 'em interesting now."

Many teachers saw their **students practice self-directed, inquiry-based learning** through their projects. These teachers guided their students to ask questions and look for answers themselves rather than "expecting the right answer" from their teacher and, in some cases, accepting "that there wasn't necessarily a correct answer for some of their testing." One teacher also observed their students asking each other questions: "they talked to each other: 'Well, why is your plant doing better than my plant? What did you do differently?' and I didn't ask them to do that. I was hoping that that would happen. But they were actually really willing to share with each other."

> **"I didn't tell the kids that, 'cause they needed to find that out: that [planaria] will asexually reproduce and sexually reproduce. So I just let them go. And then the kids were like, '[Teacher], we have like three, I only cut them in half. We have three. What happened?' I said, 'You tell me what happened.' So they were excited about that."**
>
> Teacher Interview

Teachers and students alike appreciated the self-directedness of the projects. One teacher observed that their students were "more invested" and "empowered" in the project because they had agency in designing their experiment. Another said, "I think it's good for them to kind of learn on their own, come to it on their own."

> **"For me, that was really nice, just seeing them sort of process and try things and retry and even if, like, their end product was sort of a big failure, they still learned from it because … they realized what didn't work, you know? But they still understood the process of you try, you modify, you try again, you modify. So in that respect it was really good."**
>
> Teacher Interview

Three teachers emphasized the ways in which their students **learned from failures or setbacks** through the project, solidifying their **problem-solving skills**. The most common setback was students' planaria dying; in response to this setback, teachers and students shared planaria with one another, explored the factors that may have caused the deaths, and brainstormed changes to their experiments that would keep the planaria alive. The

students growing plants faced similar challenges with plants dying. Teachers observed their students problem-solving in real time to overcome these challenges. In an interview, a teacher recalled:

> "There was one group who [had] an issue with the watering, it got way over-watered and the roots rotted. And then we had this really hot day in the greenhouse … they were trying to salvage it and then it got obliterated because it was just too hot. … They were really crestfallen. So another group said, 'well, we did something similar, so why don't you take a cutting from ours so you don't have to start from scratch?' And I thought that was fabulous. … It became—the pun intended, I guess—more organic for the experience."

Some teachers observed their **students developing a sense of responsibility**, especially when working with living things like planaria and plants that had to be cared for regularly: "The idea of having a lab partner and one of them being on a field trip or out sick and making those arrangements to have the lab partner or maybe somebody that's not their lab partner go and take care of something for them." One teacher noted that this skill will be important for seniors, who are "going into mostly STEM majors," as it prepared them for "having that lab experience where they're not having their hand held as much."

Teachers also observed students **learning about and making connections to the RM&B field.** One teacher shared in a survey response that "many **[students] expressed an interest in the [RM&B] field** of study." Another explained, "the lab work and exposure to regenerative medicine projects were very helpful to give ideas to work on with students and to help motivate them toward careers they might not have thought of."

> **"People in the field want students who can be collaborative and have systems thinking. They … can come from different backgrounds and subject areas and skill sets."**
>
> Teacher Post-PD Survey

Four teachers described the ways in which they observed their **students make connections between their in-class projects and real-world applications** of the skills or technologies they used in their experiments. Students who worked on the plant project were able to connect different ways of cutting plants (e.g., smashing versus cutting cleanly) and their regrowth to different types of injuries in humans and how regenerative medicine can be used to treat them. This teacher also observed their students draw connections between grafting plants to medical transplants in humans.

Another teacher explained that learning about stem cells and differentiation is "not something you typically get really deep into in a high school biology class," but that they had discussions with their students that helped them connect the planaria project to these principles of regenerative medicine.

> **"They all understand that in response to distress, injury, trauma, that cells can repair, they can grow, and—in some cases—grow back. And I think that was a big part of it, they didn't really understand that in the things that I've done in the past. And so they know that now."**
>
> Teacher Interview

One teacher helped their students connect their project work to creation of synthetic insulin used to treat diabetes because they were using the same technique in their lab project. The teacher reflected that this "helped [students] to see the social factors that go along with this. So they were learning about how insulin is made, how people get insulin, how expensive it is, what are processes or steps that could be made to make it less expensive. … [These ideas] were good revelations for them."

Wide-reaching impact

The impact of the Tech for Teachers PD program and RM&B project implementation spread far beyond the seven teachers and 360 students who directly participated. A couple of teachers reported that they **used skills they learned through the PD as well as the equipment they received in many of their classes,** not just the classes that engaged in the RM&B projects.

> **"What I didn't expect was how much our students got out of it and how much my other students got out of it as well. Like, some of the lab ideas … I was using with my Chemistry kids, I was using with my general Biology kids."**
>
> Teacher Interview

One teacher described how they used ideas they learned through Tech for Teachers in many of their classes, not just those that did RM&B projects. They explained that even students who did not directly participate in the projects "benefitted from … the supplies as well, like my microscopes." They observed, "it didn't just impact the teachers, it impacted the students that were doing the project and also my other students as well."

Another teacher started a STEM Club at their school, allowing students to come to their room and work with the equipment, such as 3D printers. They also allowed students from

different classes to work with planaria through the STEM Club if their own classes were not doing the planaria project. They noted that some students "might come almost every day after school" to work on projects with the new technology:

> "The goal is to do more projects. … I have students from previous years, like, 'oh, I wanna do that,' like the planaria. And they'll come and they'll do it on their own. And so I'm kind of putting that under the whole guise of the [STEM] Club too, 'cause I'm trying to attract more students and if they can't stay after, I want them still to have the same access to things. So they come during their study or my prep or whatever. … My goal for some of the students as part of the STEM Club-ish, is to have a maker space for them for science. … Like, we had some anatomy students that wanted to 3D model cell parts and different tissues, and they wouldn't have had access to doing this without this equipment."

One teacher had their honors students **present their projects to another class** with students who have Individualized Education Plans or are in ELL programs in their school. For their presentations, the students designed interactive activities for their peers to teach them about their projects:

> "I had prepped my class, you know, like a week or so ahead of time. I'm like, 'All right, so … kids are just gonna come over to your lab tables and you're gonna tell 'em about what you did.' And, I'm like, 'They have to touch things and they wanna do things. So not only do you need to be able to explain the idea, but they need to be able to, like, do something when they're at your lab table.' … And so they just came up with all these little creative things where these kids—who have never seen these tools or touched them or anything—and they were all of a sudden doing something at each lab table. … The kids who were presenting, like, they're all honors-level kids that I have. But you've gotta be able to talk and communicate and show these other kids what you're doing and how much fun you had and what you learned."

Teachers **shared information about the Tech for Teachers program, their projects, and their equipment with other teachers** in their schools as well. Two teachers said they had other teachers come into their classrooms to see their projects in action and some reported that they shared ideas with their department colleagues or Professional

> **"I have a couple teachers that I'm close with here that I've shared equipment or ideas or experiences with that are very open and hoping to maybe do the program in the future."**
>
> Teacher Interview

Learning Communities. One teacher also suggested that their colleagues visit UNH to "see what's going on."

Some teachers **shared information about the program with colleagues at other schools**, too, through informal conversation and social media. One teacher had a group of teachers from another school visit their class because the group was interested in starting PBL at their school. Another explained, "I've told every teacher in Manchester that I have seen, 'you guys need to get that STEM-MoBILE at your school.' I said, 'cause it's a fabulous thing. I said, 'UNH has so much to offer, we need to take advantage of it.'"

> **"I have told every science teacher that I can talk to, like, 'you need to do this. Like, this is so cool.' So one of my [teacher] colleagues is doing the program this summer. So I said, 'you'll love it.' I said, 'it's fun stuff.'"**
>
> Teacher Interview

Many teachers were able to **present their projects with administrators within their schools and at the district level**. Several described their principals as "supportive" of the program. As noted above, teachers also described support from district-level staff who visited their classrooms.

Effective and Supportive Program Model

Feedback about the entire program was overwhelmingly positive. Teachers highlighted several aspects of the program model that they found particularly effective and supportive.

Opportunities for collaboration and interaction with other teachers

In interviews, all seven teachers expressed gratitude for the opportunity to engage with other teachers during the program and over the course of the school year while implementing their RM&B projects.

> **"I think the best part of Manchester CREATES was being able to have time to collaborate with other teachers."**
>
> Teacher Interview

> **"I also appreciate being able to collaborate with teachers. I don't think in Manchester, we have enough time to do that."**
>
> Teacher Interview

They appreciated being part of a cohort of teachers going through a shared experience. One teacher shared that going through the program with a colleague at their school was "very, very powerful" because they could exchange ideas with each other throughout the process. Another teacher explained that they would "compare notes" and share the physical resources from Manchester CREATES, like microscopes, with the other participating teachers at their school.

A few recalled that other PD opportunities have lacked opportunities for teachers to collaborate or discuss the content with one another; one felt that the time for conversation in Tech for Teachers was "a privilege" and one of the program's "luxuries." Four teachers explained that while they may have opportunities to share ideas with other teachers outside of work during their personal time, they appreciated the opportunity to do this "on the clock." One emphasized that the Tech for Teachers program provided them with "time to collaborate" and "time to not be distracted … by five other things in the same hour."

> **"I've been teaching for 22 years and … I think the majority of my teaching, I never communicated with people more than, 'hi, nice to meet you' at a workshop, and then that's it."**
>
> Teacher Interview

Building a Network

In addition to collaborating with colleagues, a few teachers also shared that they appreciated the connections formed between the RM&B industry, higher education, and MSD teachers within and across schools. They appreciated the industry and higher education professionals' "willingness to be supportive of us," which is "not something that we typically experience – we're usually kind of treated like bottom feeders." Another expressed appreciation for their connections at other MSD schools, especially when it came to sharing planaria and replacing populations that died. One teacher shared that the opportunity to "go into labs over at UNH Manchester was also really cool."

"I feel like I have seven other teachers who I can contact for not only stuff about the regenerative medicine, but, you know, anything biology-related, that type of thing. So, I would say that's the main thing, is just, you know, being put with all of those other teachers and just spending all that time together. It gave us the chance to know each other personally, professionally, where it wasn't there before."

Teacher Interview

"We each had a different focus and we're each looking at it from a different thing, but the nugget of the regenerative medicine, right? That brought us together and we were able to collaborate in a more meaningful way. As opposed to sharing a lesson that I did, we're now sharing thoughts and ideas."

Teacher Interview

"All the speakers [at Tech for Teachers] were fantastic, and meeting people and feeling not so isolated as a teacher in the school has been extremely helpful. I definitely feel like there's more of a village supporting the students."

Teacher Interview

Ongoing engagement from staff and supplies to support implementation

Teachers appreciated that program support did not end after the Tech for Teachers PD session concluded: they received ongoing support during the school year.

Teachers greatly appreciated the **Manchester CREATES staff and facilitators**, especially Shannon. They explained that Shannon helped them "not feel like I had roadblocks," and come up with "affordable, doable things we can do with our students." Teachers described Shannon as "a Swiss army knife of experience," "a joy to work with," "an amazing resource," "an absolute inspiration," and "phenomenal."

> **"It was really like no PD I've ever had before in [terms of] that year-long continuous support."**
>
> Teacher Interview

The **physical supplies** teachers received from Manchester CREATES also played an important role in ensuring project implementation success. In post-PD surveys, two teachers noted that the physical supplies they received through Tech for Teachers would be essential resources supporting their projects. One teacher explained that they felt "supported, both in background but also the materials."

> **"We ended up with supplies so we could do it with our kids. I was missing like, the most basic supplies, like microscopes and specimen containers and like, just the basics we didn't have to make it work. So that was a plus."**
>
> Teacher Interview

As anticipated, the materials proved valuable for project implementation: in post-project interviews, a few teachers highlighted the importance of the "awesome supplies,"—such as microscopes, 3D printers, and live planaria—Manchester CREATES provided to them.

> **"We got new microscopes which were also exciting to use and the general process of learning all the equipment and applying it to regenerative medicine was really fun."**
>
> Teacher Post-Project Survey

One went so far as to explain that the provision of supplies "sealed the deal" to convince them to participate in the program. Another reflected, "I'm used to saying, 'well, we can't do that because we don't have those resources.' … I needed more test tube holders and [Shannon] designed a test tube rack and I printed it out."

> **"I would have had a hard time doing [the project] without those microscopes with the screens … 'cause it would've been the whole class sharing, like, two borrowed dissection microscopes that were binocular-type. And I always worry about those things … you know, pink eye is spread so easily. Whereas with the screen, it's like, I don't have to worry about it, you know? So yeah, that was a big hook."**
>
> Teacher Interview

> **"I appreciate beyond measure the fact that I could dream and then plan and have all the 'stuff' that I needed to do something like this."**
>
> Teacher Post-Project Survey

> **"Access to new equipment like digital microscopes reached a population of students that typically did not enjoy science."**
>
> Teacher Post-Project Survey

Immersive, extended professional development approach

Teachers cited a wide range of Tech for Teachers PD program features that differentiate it from other PD programs they have attended in the past. Key features included the extended time frame during which they could practice skills and, as mentioned above, the opportunities to connect with other teachers.

> **"It was some of the best PD I've had in decades. It was really fantastic."**
>
> Teacher Interview

Teachers appreciated that "chunk of time" they had for Tech for Teachers compared to "regular district PD." They appreciated that Tech for Teachers "wasn't rushed," explaining that "it's hard for anyone, at any level, to learn anything and be able to implement it in a few hours." Another explained that in other PD they have attended, "they just give you a bunch of information

and they don't give you time to really process the information or the support to execute it," going on to say that the Tech for Teachers model is "an entirely different model, and an effective one." Another teacher shared that in contrast to Tech for Teachers, "the district-mandated PD is usually … I personally don't find it very useful."

> **"A lot of times, PD, you come in, you sit down, someone does a PowerPoint and you walk out. [In Tech for Teachers,] I got to plan, execute, do, and play."**
>
> Teacher Interview

Two teachers compared Tech for Teachers positively to other extended, immersive PD programs they had attended, including one through UNH's Isle of Shoals program. One shared "the only other professional development that I think has ever been as impactful is … an immersive weeklong program" and the other noted "the only thing that could probably top this for me was when I spent a week doing … a one- or two-week-long … teachers' course. … It was a similar experience."

A few remarked that while they had attended PD in the past, Tech for Teachers was unique in that they felt able to implement what they learned. One explained, "I've had time in other PD, but not the ability to implement what I was learning." Another emphasized that "the topics are applicable to the classroom and we actually created something that we could use in the classroom."

Program Feedback

Teacher Post-PD Survey Feedback

> **"I wanted to be able to design something I could actually implement and I did."**
>
> **Teacher Post-PD Survey**

We asked teachers to rate how well Manchester Tech for Teachers did at meeting its PD goals on a six-point scale of *not at all* to *excellent*. All or most teachers rated the program as *very good* or *excellent* at providing information about the RM&B resources that exist in Manchester and beyond, modeling how RM&B can be incorporated into the school classroom or lab, and helping teachers overcome challenges to teaching about RM&B in the curriculum (Figure 11). There was room for improvement on explaining how RM&B related to the Next Generation Science Standards (NGSS), with about half of the teachers responding *fair*. No teachers selected *poor* or *not at all* for any item. They reported that **overall, their participation in the program *definitely* (5) or *somewhat* (2) accomplished what they were expecting, and all seven would recommend the program to other teachers.**

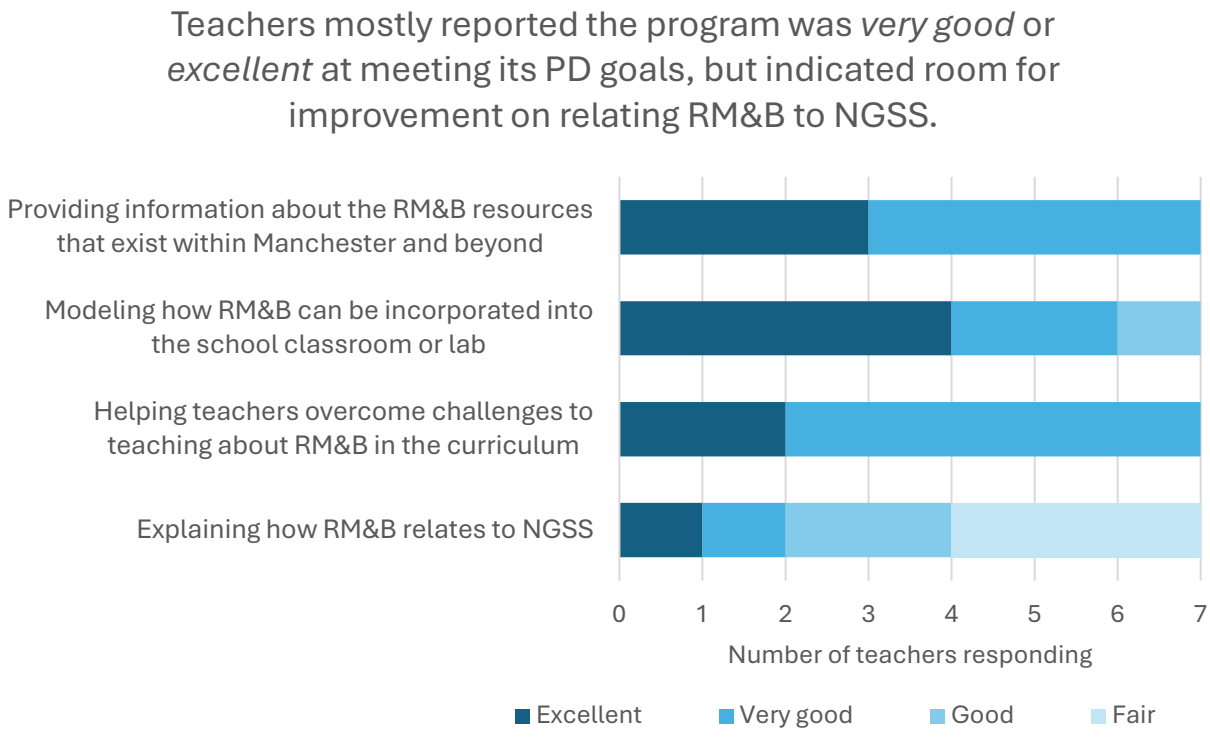


Figure 11. Teachers' ratings of how well the program met its PD goals (n=7).

Teachers also rated their agreement with statements about program facilitation on a six-point scale of *strongly disagree* to *strongly agree*. Most of the teachers *agreed* or *strongly agreed* with the items, all of which were positively worded, indicating a high level of satisfaction with program facilitation. The highest agreement was with the statements about guest speakers addressing important topics of the content area, and facilitators' addressing topics in sufficient detail and responding to learners' questions with appropriate and relevant answers (Figure 12). A few teachers did not agree as strongly or disagreed with the statements about facilitators asking questions which were relevant to topic objectives and resulted in lively and relevant discussion, facilitators creating an atmosphere in which all learners participated, and facilitators keeping the discussion focused; however, none *strongly disagreed*.

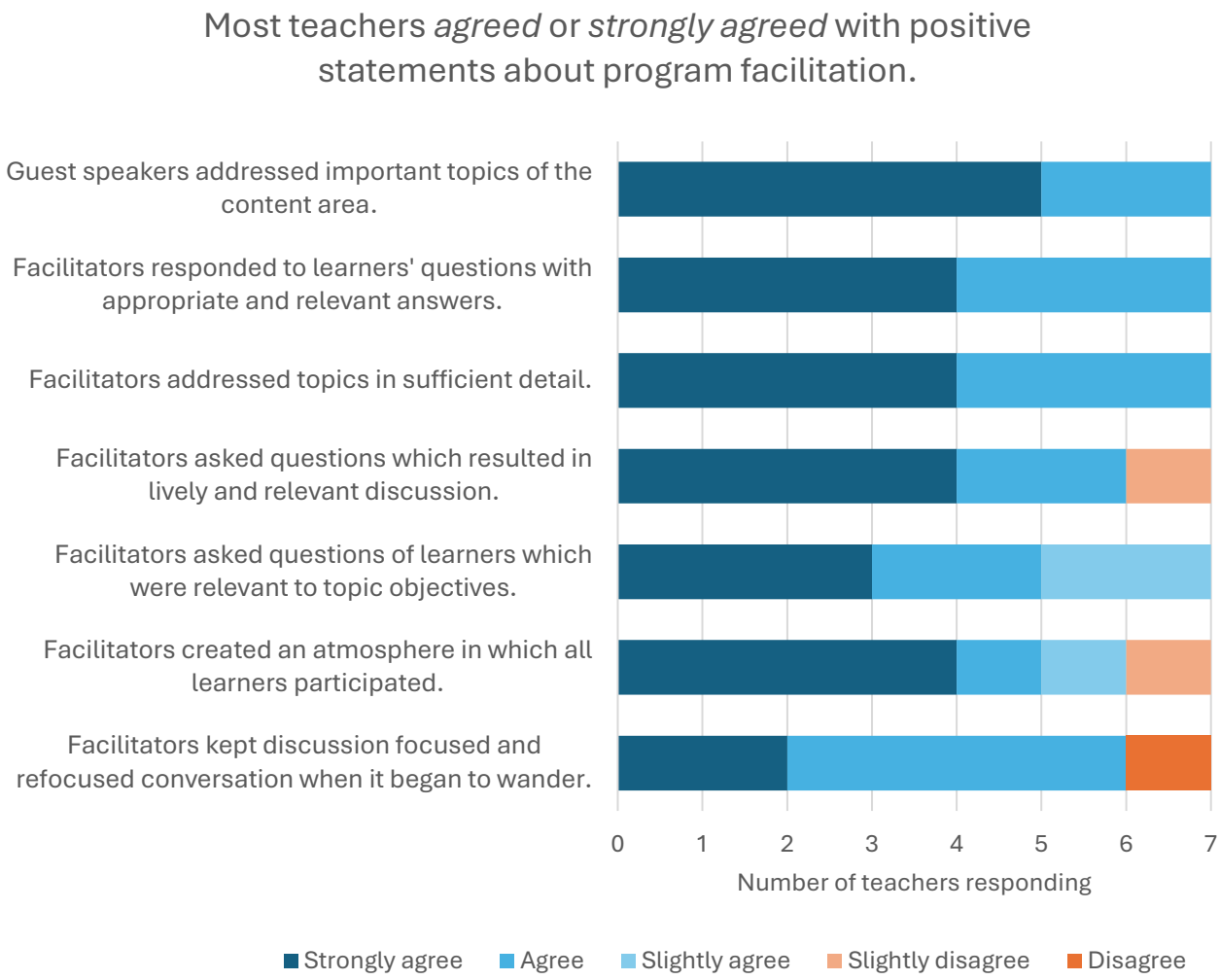


Figure 12. Teacher ratings of agreement with positive statements about program facilitation in descending order of average agreement (n=7).

Teachers' comments in the post-PD survey included mostly positive feedback on the experience, highlighting their appreciation for the opportunity for hands-on learning in the lab and collaboration with others. Two teachers commented that they appreciated the opportunity to design lessons they would be able to implement in their classrooms. Others noted that the program was well-organized, provided helpful information and supports, and took teachers needs' into account. One teacher provided more detailed insight on the PD facilitation in their post-project interview. They suggested that PD facilitators could support teachers as learners by scaffolding learning and by asking teachers, "what do you need to be able to learn?" This teacher explained that this would help facilitators make necessary accommodations to support everyone.

Although teachers overwhelmingly expressed appreciation for time to connect, one teacher did note that it is important for facilitators to intentionally maintain some structure for connection time during PD sessions. This teacher explained, "One issue … I found is that when you put a bunch of teachers together … they like to complain a lot. And I think there's definitely space for that venting or sharing experiences or things like that. But at a certain point … I would just like to get going a little bit. … I felt like the wheels were spinning a little bit." (This teacher also noted that this is "no one's fault," but rather a reality of the lack of time for "teachers in Manchester to talk to each other.")

Teachers also provided constructive feedback Tech for Teachers' structure and content. Two proposed adjusting the schedule to make it less "draining" and another observed that some of the modeling was too fast-paced. One of these teachers suggested, "I think this would have benefitted from shorter days or a single week in the summer with the remaining hours dispersed in other ways throughout the school year."

While teachers generally felt prepared and able to implement what they learned in the PD, one felt there was too much focus on activities that are more difficult to implement, like 3D printing. For another, some content felt irrelevant and disorganized. Several teachers suggested dedicating more time to instruction on teaching practices and others suggested more instruction on biotechnology teaching techniques. Two suggested spending less time on PBL, although one noted that this suggestion may depend on the group of participants.

Suggestions for Program Improvement

In surveys and interviews, teachers offered a variety of suggestions for program improvement, particularly how the program can better support teachers in the future.

Provide lesson plans, project ideas, lab materials, and concrete examples.

A couple of post-PD survey comments suggested providing more examples of completed projects, more time to work on lesson plans, and more time for instruction on specific labs; more teachers shared similar feedback in the post-project surveys and interviews.

After project implementation, teachers' survey responses still echoed these post-PD comments. They suggested providing more information on "how to effectively plan projects and implement them" as well as "fully complete lessons/projects that I could then adapt or fold into my current teaching." One noted that providing "pre-formed labs" (similar to those in the STEM-MoBILE) would make labs easier for teachers with short class periods to implement. Another suggested providing "basic class lab supplies."

In the interviews, one teacher suggested providing real examples of PBL projects as well as bounds that can help teachers plan if the project feels too open-ended. This teacher explained that the example projects could be from past Manchester CREATES participants and could include "a project that actually worked in the classroom, … here's how they did it, how they actually did it in the classroom, not just what their lesson plan looked like."

> **"Ideally these would be lessons that have been used in the classroom and/or are ready to be implemented in the classroom. This would help to give us ideas on how to plan our own lessons."**
>
> **Teacher Post-PD Survey**

In the post-project survey, several teachers also suggested that it would be helpful to have more time to work in the lab on "longer projects" or to "try out new lab ideas."

Through the school year and beyond, stay in touch with teachers to provide continued support, engagement with the program and the RM&B industry, and opportunities for connection among teachers.

Teachers appreciated the ongoing support and communication they received from the Manchester CREATES team during the school year following the Tech for Teachers PD and expressed a hope to stay connected with Manchester CREATES in the future.

In their post-project interview, one teacher suggested that during the school year, program staff could stay engaged with teachers through additional site visits over the course of the project rather than just one time at the end. They explained that this would help emphasize the importance of the PBL *process* rather than focusing solely on the *outcome*: "I think [staff] need to see the middle and the end. … Like to see the work as it's going on, and talk to the kids and be like, 'what happened?'"

Additionally, one teacher suggested in the interviews that the program provide additional PD on district-allocated PD days during the school year in order to extend teachers' learning, which would also provide time for teachers to connect with one another: "Maybe two PD days in the future. … It doesn't feel right just closing it and moving on. Something this big I feel like still needs communication in the future."

In the post-project survey, several teachers suggested that Manchester CREATES staff continue to be available to answer their questions as they implement projects in the future. One remarked, "I am hoping that I can still reach out to Shannon as she is an awesome resource for us." Another said they would appreciate it if the program team would continue to serve as a resource or "sounding board" in the future.

Some teachers also suggested providing opportunities for them to stay up-to-date with RM&B research and innovation. They suggested inviting teachers to "attend lectures to hear new research to stay current" and that the program should "continue to invite us to workshops that give us opportunities to hear about new research." One teacher felt it would be helpful to "connect me with community partners, find speakers to bring into the classroom, or locations to bring students on a field trip."

In post-project surveys, several teachers suggested that Manchester CREATES continue providing time for teachers to connect with each other and share ideas. They explained that it would be helpful to have opportunities to "share what others have found success in" and "give a chance to share with others."

Discussion & Recommendations

The findings presented in this report demonstrate that Manchester CREATES Tech for Teachers is achieving its anticipated outcomes outlined in the logic model. Teachers not only felt more prepared to implement their RM&B PBL projects in the classroom, they also became more confident in their STEM teaching more generally. Although teachers' post-PD feedback suggests room for improvement in relating RM&B to NGSS, the average rating of their understanding of the relevance of RM&B to NGSS increased by 35%.

Teachers described how they collaborated as a cohort to support each other in trying something new and sharing information, resources, and experiences across classrooms and schools. Some also accessed people and resources from the regional RM&B ecosystem to facilitate the introduction of RM&B to the MSD school community, although the program's support for teachers in establishing and sustaining connections within higher education and industry could potentially be strengthened. And as an epilogue to the positive findings already presented here, three members of Tech for Teachers' first cohort served as staff for the 2025 Tech Camp student programs and encouraged their colleagues and students to join them in this year's Manchester CREATES activities.

Below we present key findings from this year's evaluation of Tech for Teachers, and recommendations for program improvement going forward.

Teachers gained knowledge, awareness, skills, and confidence

Key Finding: There was a substantial increase in teachers' ratings of their RM&B knowledge, ability, interest and awareness from before to after PD. The greatest increases were in awareness of RM&B partners and resources within NH (+93%) and in their ability to incorporate hands-on activities/labs about RM&B in the classroom (+81%), get students engaged with RM&B content and methods (+70%), and teach their students about future jobs in RM&B (+67%). After PD and project implementation, all seven teachers agreed to some extent that they have sufficient knowledge to provide their students with a strong foundation in RM&B concepts.

Key Finding: Teachers gained confidence teaching STEM from pre-PD to post-project implementation. They *agreed* more that they can answer most STEM questions their students ask (+24%) and that the STEM concepts they teach their students reflect the latest STEM advances (+21%). They *disagreed* more that they find it difficult to explain to students why and how specific research methods are applied to address specific STEM questions and/or problems (-35%) and need more knowledge about STEM concepts to be an effective STEM teacher (-29%).

Key Finding: By post-project implementation, all the teachers felt at least *somewhat prepared* to implement PBL in the classroom, an improvement from before PD. Most of the teachers reported that they find PBL somewhat more effective than a traditional instructional model, and that it has at least some positive influence on students' reception of class material. Several described a high level of engagement from their students when working on their RM&B PBL projects. However, they varied in their perceptions of PBL requiring more or less work to plan and implement compared to a traditional instructional model, and no clear trends emerged regarding changes in specific classroom practices related to PBL. The teachers' comments regarding PBL reinforce that they have a wide range of thoughts on it and experiences with it.

Wide program reach and impact on students

Key Finding: All seven teachers in the first cohort successfully implemented their projects, and in doing so brought RM&B to 18 classes and 360 students, or about 5% of all middle and high school students in the district. In addition to this direct reach, teachers reported using the skills and equipment provided by the program to benefit other Manchester teachers and students, indicating an even wider indirect reach. Further, most of the teachers planned to implement additional RM&B projects in the future, which would expand the program's reach even more.

Key Finding: Teachers saw their students practice self-directed, inquiry-based learning through their RM&B projects. Some observed that students learned from failures or setbacks, developing their problem-solving skills, or gained a sense of responsibility, especially when working with living things like planaria and plants that had to be cared for regularly. Teachers described how students made connections between their in-class projects and real-world applications of the skills or technologies they used in their experiments in the field of RM&B.

Connections to the RM&B ecosystem

Key Finding: During the 2024-2025 school year, more teachers advised students on RM&B secondary education, research or career pathways and shared resources for teaching RM&B with other teachers than during the previous school years. They hosted visits from the UNH STEM-MoBILE and ARMI scientists and educators at their schools and reported them to be effective at engaging their students and raising awareness of local opportunities in the RM&B industry. However, some teachers felt they were not connected enough to regional RM&B higher education and industry representatives to pursue class visits or field trips or lacked the time.

Recommendation: Some teachers see a larger potential role for the program in establishing and sustaining connections with higher education and industry partners, beyond sharing contact information or making an initial introduction. These teachers did not always feel comfortable reaching out to higher education and industry contacts independently, had time constraints that prevented independent relationship building, or tried to make contact but did not hear back. Consider additional program support throughout the year to help teachers make arrangements for guest speakers and field trips and/or additional program structure that would make coordinating these opportunities a lighter lift for teachers.

A successful program with opportunities for continued improvement

Key Finding: Teachers greatly appreciated the support they got from Manchester CREATES during the PD and after PD during school year; they identified this aspect of the program as a unique strength compared to other PD in which they had participated and credited this especially to Shannon's role. Providing the equipment to make the projects a reality was cited as a key support. Additionally, they highly valued the opportunity the program gave them to connect and collaborate with other MSD teachers within and across their schools. They also welcomed the chance to connect with RM&B experts from the UNH faculty and local industry. The teachers expressed a desire for these program supports to continue through their first school year after PD and beyond to sustain a positive trajectory.

Recommendation: Teachers provided several suggestions that would increase project implementation support and sustain a higher level of engagement with Manchester CREATES throughout the school year, including staff visiting classrooms more frequently, helping teachers connect with RM&B professionals, and providing additional PD sessions.

Key Finding: Despite all seven teachers successfully implementing their RM&B projects, all seven also reported a lack of time as at least *somewhat of a barrier*, including limited planning time and class time. Other frequently reported barriers were curriculum pacing and alignment, need for more training/PD, limited equipment and physical space, and difficulty assessing students. Some described other challenges, such as facing unexpected situations, managing new content and a new type of classroom project, and finding a balance between allowing students' free inquiry and setting parameters for the experiments to improve feasibility.

Recommendation: The serious time constraints public school teachers face are well known and beyond the control of the program. However, additional PD may help to address some of the other barriers they experienced, which may in turn make RM&B project implementation a less time-intensive endeavor for them. It may also be helpful to provide teachers with more detailed lesson plans and labs that they can easily implement in their classrooms with less preparation. Previous experience implementing the project should also help the next time around.

Conclusion

The first year of Manchester CREATES Tech for Teachers showed strong early success in bringing RM&B into Manchester classrooms and demonstrated that the NH CREATES model was effectively replicated in Manchester. The PD prepared teachers to incorporate RM&B into their curricula, increased their confidence in STEM instruction, and strengthened their PBL skills. As a result, hundreds of Manchester students were able to engage in hands-on, inquiry-based RM&B projects. Feedback from the initial cohort of teachers offers guidance to the program for helping to address the challenges they and future participants may face in implementing RM&B projects and connecting with the RM&B ecosystem. With continued investment in teacher PD and community partnerships, Manchester CREATES is well-positioned to expand its impact going forward.

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Appendix A: Manchester CREATES Logic Model

MANCHESTER CREATES LOGIC MODEL (TEACHERS)

INPUTS	ACTIVITIES	OUTPUTS	SHORT-TERM OUTCOMES	MID-TERM OUTCOMES	LONG-TERM OUTCOMES
• NIH SEPA grant award for NH CREATES & Build Back Better grant award for Manch CREATES • UNH Manchester's Biotechnology Innovation Center • UNH Durham and UNH Manchester faculty and staff content and program expertise • Manchester School District (MSD) engagement	• **PD for RM&B and project-based learning (PBL) with MSD teachers** • Tech Camp summer programs for students • Single-session RM&B focused activities and demonstrations	• **Cohorts/teachers completing PD** • **RM&B PBL projects implemented (classes, grades, students)** • Tech Camp programs held, students participating in Tech Camp • Organizations participating in single-session activities and demonstrations	• Teachers feel prepared to implement RM&B PBL projects in the classroom • Teachers more aware of RM&B concepts, local resources, and job opportunities for students • Teachers value alignment of RM&B PBL projects w/NGSS • Teachers feel connected to an RM&B cohort and network	• Teachers implement RM&B PBL projects in the classroom • Students gain STEM identity and interest in RM&B and STEM careers • Teachers access RM&B resources and opportunities, facilitate student access to them • Teachers become PD leads and ambassadors for the program and RM&B in general	• MSD adopts RM&B PBL projects into science curricula • MSD links into regional RM&B "ecosystem" of P-12, higher ed, and industry • MSD prepares the student body for RM&B education, jobs, and careers • MSD grads participate in Manchester's future RM&B workforce

OBJECTIVE To build a highly qualified regenerative medicine and biofabrication (RM&B) workforce in the Manchester NH region, thereby supporting expansion of the regional biofabrication and regenerative manufacturing cluster.

Appendix B: Effective Practices and Advice for Future Projects

Manchester CREATES Tech for Teachers:

Lessons Learned from the First Year of RM&B Projects

We conducted virtual interviews with the first cohort of participants in Manchester CREATES Tech for Teachers after they completed implementation of their RM&B projects in their classes. They shared a variety of practices that supported project success as well as things they would do differently if they did their project again, summarized below.

Intentional group assignments

One teacher grouped students to include a variety of strengths and skill levels in each group and gave each student a specific role or responsibility within the group based on their interests. They reflected, "every kid kind of gravitated to something that worked for them." This teacher also noted that they avoided grading students as a group, opting instead to grade students on their individual work as part of the group.

Another teacher allowed their students to choose their own groups this year. They mentioned they might "group the kids a little differently" if they did the project again, although student self-selection did push some students to "step up" because "they weren't having someone hold their hand." A third also commented that instead of giving groups planaria to care for next time, they would give each individual student their own planaria to help them feel responsible and to reduce the issue where groups have "some people that do absolutely nothing and other people that do everything" and so the teacher would have "a little better idea of what each individual student is contributing."

Scaffolded learning and pre-work

One teacher did the spinach de-cell re-cell project prior to the planaria project as an introduction and to build excitement for the planaria, which they described as "a great lead-in." This teacher also used "big whiteboards" to do pre-work that allowed students to brainstorm things they knew and didn't know prior to starting the project.

Another teacher said that if they did the project again, they would "grow some plants in the beginning of the year" to help the students learn "what a plant needs and what the plant parts are" to prepare for the project and establish background knowledge. A third teacher hoped to expand their RM&B project in the future, incorporating more scaffolding. This teacher envisioned doing the E. coli cell culturing project as "one of the stops" in teaching about RM&B rather than "the end goal." They explained that they would use the more structured E. coli project to help students build an understanding of RM&B technology and then do a less-structured lab afterwards to provide "more chance for the student autonomy and discovery."

Leveraging the "gross factor"

One teacher liked to leverage "the gross factor" in science learning, like the idea that there can be microscopic organisms in water that students never knew were there. Another shared that "the earthy part of science" is good for their students, emphasizing the experiential nature of hands-on science learning.

Balancing student choice with teacher-defined bounds

One teacher found a successful balance between letting students make decisions about their projects while maintaining a few bounds that kept the projects feasible: "They chose the plant, they chose the part, they chose the condition. I limited them to two conditions because I didn't want their data to get so confused."

Along the same lines, another teacher said they would provide more structure for their students next time by limiting variables in student-designed experiments. They explained, "I think in the future I would give them some options of factors to change and make it mandatory that they chose one factor and explain why they were interested in that one factor instead of allowing them to come up with a factor to change on their own." They believed this would help support students who had trouble understanding the difference between independent and dependent variables.

Two other teachers hoped to give their students more choice and responsibility for the project in the future. One wanted to "lean on the more student discovery part of it" and the other explained that they "would probably have the kids do a bit more" even though it can be "easier for me to do things for them," like preparing the food for the planaria.