Assessing the Landscape for Creating High School STEM Research Experiences within Living Laboratory

White Paper

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Introduction

This White Paper is based on proceedings from the *National Living Laboratory Workshop: High School Research Experiences in Living Laboratory* - a convening of professionals who wished to share resources and explore opportunities to involve high school students in the Living Laboratory model. The workshop was funded by the National Science Foundation (under Grant #1640726), and took place on October 7, 2016 in Boston, Massachusetts. Following the introduction, the structure of this white paper follows the agenda of the workshop, with each section summarizing the main themes from that portion of the agenda, as shown below.

Meeting agenda	
8:30-8:40	Welcome, goals, and logistics of the day
8:40-9:10	Motivations for integrating high school students within Living Laboratory
9:10-9:30	Findings from the National Living Laboratory front-end evaluation survey
9:30-10:15	Living Laboratory participant perspectives: Community experiences and insights
10:15-10:30	Break
10:30-11:30	Beyond Living Laboratory: Lessons from the field
11:30-12:00	Barriers and challenges
12:00-12:45	Lunch
12:45-1:45	Teen outcomes
1:45-2:30	Professional outcomes
2:30-3:15	Program logistics breakout
3:15-3:30	Break
3:30-5:15	Program co-creation

About Living Laboratory

Living Laboratory is a collaborative education model that promotes child development research in informal settings, immerses the public in scientific discovery, and builds partnerships between museums and research institutions. The model, which involves a museum collaborating with a child development researcher who leads research studies in the Museum, was developed at the Museum of Science, Boston in 2005. It was refined and disseminated with National Science Foundation (NSF) support (DRL 0714706 and DRL 1113648). More than 750 professionals in at least 48 U.S. states have joined the Living Laboratory community.

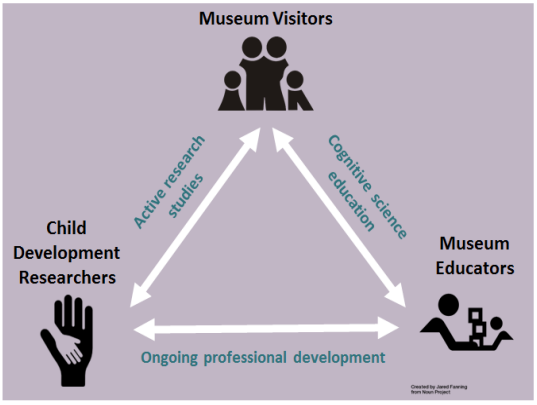

Figure 1: Living Laboratory's mutual learning engages child development researchers, museum visitors, and educators.

The text box below shares definitions of some important Living Laboratory terms used in this document.

Living Laboratory Terms
Essential Element: One of the nine criteria of the Living Laboratory model (see Appendix A).
Greeting: A brief mutual professional development opportunity in which museum staff and researchers check-in and "warm-up" for interactions with museum visitors through dialogue, feedback and inquiry.
Museum staff: Professional personnel affiliated with a museum or informal education organization. These professionals include, but are not limited to museum educators.
National Living Laboratory community: The group of professionals across the country who have accessed National Living Laboratory resources or attended events.
Researcher: Professional personnel affiliated with an institution that does active research, such as universities, hospitals, and independent firms. Research fields typically include social psychology, cognitive neuroscience, educational psychology, developmental psychology, or cognitive science. Researchers may be students, Principal Investigators, or administrators.
Research toy: A facilitated, hands-on activity based on published research through which museum visitors can engage in a research-like process without having their data collected. Research toys are often led by museum staff.

Why teens?

The conference focused on research experiences for teens because:

1) Living Laboratory has successfully engaged undergraduates in science research and communication. The project team expects similar outcomes could be supported for teens.
2) Research suggests that early exposure (K-12) to authentic research experiences positively correlates to STEM related career choices in academics and beyond.[1]
3) Infrastructure for on-boarding and supporting teens already exists within many museums and, to a lesser extent, research institutions.[2]

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[1] Early exposure to and interest in STEM increases the likelihood of scientific interest and STEM engagement later in life (Tai, Lui, Maltese, & Fan, 2006). Tai (2016) found that 94% of scientists and 93% of graduate students reported first becoming interested in science in grades K-12, with only 6% and 7% (respectively) reporting the onset of interest as undergraduate students. The majority of scientists (52%) and graduate students (56%) in this study reported that they first became interested in their career discipline in grades 9-12, compared to K-8 grade (29% of scientists, 23% of graduate students). Tai's evidence suggests that fomenting interest and engagement in STEM during high school can sustain interest into adulthood.

[2] Many museums have robust infrastructure for employment and volunteer experiences aimed at high school students. An Association of Science-Technology Centers (ASTC) survey shows that 34.2% of ASTC member organizations facilitate employment opportunities for high school students, and 95.5% of responding members report facilitating teen volunteer programs (ASTC, 2013). As shown in Appendix B, a majority of respondents in our landscape survey had prior experience working with teens (52% researchers, n=27; 98% museums, n=64).

Conference proceedings

Motivations for integrating high school students within Living Laboratory

The conference began with introductions and a group activity during which participants shared about why they were interested in involving teens in Living Laboratory, what expertise they brought to the table, and what would help them work with teens in the future. The following figure summarizes key themes from this activity:

Why are we here?	*What expertise do we bring to the conversation?*	*What do we hope to get out of this conference?*
• Desire to learn about ways to engage teens through Living Laboratory • Curiosity and interest • Desire to engage teens • Interest in deepening collaborations between researchers and museums	• Experience with teens in museums • Experience with teens in research • Experience with teens doing research in museums • Experience with Living Laboratory • Knowledge of formal education • Knowledge of Psychology	• A concrete model for working with teens • A flexible approach that works for different organization types • Funding • Ways to reach diverse teens • Impact data

Findings from the National Living Laboratory front-end evaluation survey

Following introductions, a project evaluator shared results from the conference front-end evaluation, which consisted of an online survey of the National Living Laboratory community prior to the in-person gathering. There were 98 responses to the survey, including both researchers and museum professionals. Full survey results are in Appendix B. Key findings are:

- Many respondents—especially those from museums—had prior experience working with teens.
- Respondents' experiences with teens had almost always been positive.
- Teen involvement with museum and research organizations was most often in a volunteer capacity.
- Most professionals were interested in future high school participation in Living Laboratory, and were motivated to help teens develop skills and knowledge.
- More than half of respondents were concerned that time, money, and mentorship would be challenges to high school involvement in Living Laboratory.

Living Laboratory participant perspectives: Community experiences and insights

During this segment of the meeting, Living Laboratory sites shared about how they had worked with teens in the past. Panelists represented three types of experiences:

1. Researchers who have worked with teens
2. Museums who had worked with teens using the Living Laboratory model
3. Museums that had worked with teens in other models

The tables below share brief descriptions of each speaker's program, as well as challenges that the programs had encountered:

Researchers' experiences working with teens		
Underserved teens using the Living Laboratory model • Worked with underserved teens using the Living Laboratory model • Undergrads mentor teens as part of paid internships • Teens are interviewed • Transportation was hard for teens	University-based program for high-performing teens • Teen involved in existing, university-led program for high-performing teens • Mentorship was a challenge • Reading research papers was hard for the teen	University-based summer program for underserved youth • Underserved teens involved through a structured university program • Short term, summer only • Researchers mentor the students
Teen volunteers or research assistants • Teens serve as research assistants or volunteers • Senior researchers mentor the teens • It's challenging to get teens up to speed • There's a lot of oversight needed	Data collection assistance from high school interns • High school students intern in the lab • Undergraduates mentor teens • Teens have helped with data collection	

Museum staff's perspectives on working with teens, using the Living Laboratory model	
Science communication program and teen creation of research toys • Summer program about science communication and dissemination • A cohort of about five teens per year • Create Living Laboratory research toys through project-based learning project • Teens meet with a wide range of science professionals to learn about careers	Teens gain experience both as researchers and as museum educators • Teens are research assistants managed by a researcher • At first, teens didn't want to be in the children's area; it felt 'too young' • Now like doing research toys and reading the research papers about them because it feels like 'real science'
Teens as full Living Laboratory researchers • Youth collect Living Laboratory data in the summer • Teens are often more available in the summer than undergraduate students • Youth play the same role as undergraduate researchers, but undergo additional training • Museum-led training consists of role-play activities before teens interact with visitors	Teens meet with researchers in 8-week program • Teens do Living Laboratory greetings (conversations with researchers) • 8-week experience, 2 days/week for 14 hours/week • Teens lead research toys and read research papers

Museum experiences working with teens, not using the Living Laboratory model		
Multi-year curriculum with internship experiences • 4-year program, starting when teens are rising 9th graders • Internships in sophomore, junior, and senior years • Underserved youth • Teens are paid • The topics of the internships are varied • Teens present at professional conferences	Year-long youth development program for young women • Underserved female teens • Recruit through high schools • Focus on youth development and college preparation • 3 days/week in the summer and 1 day year-round	4-year mentoring program for college- and career-readiness • Inner-city youth • 15 in each cohort • 4-year program • Work- and college-readiness focus • Offer stipends • Teens are matched to adult mentors
Year-round exhibit development experience • Year-round • 6 weeks in the summer • Underserved teens build an exhibit for the science center • Teens are paid • Recruit through a public library	STEAM program partnered with recruitment organization • STEAM program for diverse teens • Year-round but most intensive in the summer • Outside partner recruits and does job training before teens arrive	

Beyond Living Laboratory: Lessons from the field

Four presentations addressed examples of and research about involving teens in authentic research. Summaries of these presentations are provided in the boxes below.

Authentic research experiences at the high school level
• Mentoring Programs: Some high schools have mentor experiences that pair students with researchers in the community. • Internships: Students who work with a STEM professional often shape their work into an unpaid internship, which can be valuable experience for school and job applications. • Summer opportunities: A number of colleges offer summer courses for high school students, some of which involve research opportunities. • Training: When teens work with researchers, both the adults and the students need advance training about what to expect and to build relevant skills for working together. Adults need to recognize that inspiring young people is as important as building their knowledge. • Outputs: For many of these programs, students work to create a product such as a paper, presentation, or science fair competition, combining research and research communication. • Course Credit: Some high schools award course credit for independent research projects. • Exposure to careers: Living Laboratory's partnership model could give teens access to many different types of professionals within the informal learning and research communities.

Findings about a successful model of involving diverse teens in research during out-of-school time

- Program setup: The Science Research Mentoring program at the Smithsonian Institution's National Museum of Natural History serves high-potential but low-resource youth. Students complete pre-requisite courses and then work on research projects with scientists.
- Longitudinal findings thus far: Evaluation results show that, as college freshmen, participants from this program are getting As and Bs, are asking to do research, and feel they have the skills they need for college.
- Research plans: The program now has a National Science Foundation grant to follow the students longitudinally. The research will compare against demographically similar students thanks to a partnership with the New York Department of Education. The research questions are about what students' trajectories are, whether certain program aspects are more important, and what differences there may be for different types of students. The analysis will involve creating profiles of students and that may lead to the ability to create tailored experiences.

Field-wide research about engaging women and girls in STEM

- Perception of STEM: Many people define STEM more narrowly than researchers tend to. For instance, it is common for people exclude health professions from the STEM umbrella.
- Need for longitudinal data: The field is constantly looking for longitudinal data about the impacts of out-of-school time opportunities, but it can be very difficult to secure funding for these studies.
- Novel experiences: Providing students with new opportunities is one of the strengths of informal education (McCreedy & Dierking, 2013).
- Tangible learning: Teens reported that they find science interesting and relevant but wanted different learning experiences like hands-on experiments, real-world experiences, and field trips. They would prefer these strategies to textbooks, which teens reported as the most common and least popular teaching method (Amgen Foundation and Change the Equation, 2016).
- Career exploration: A sizable gap exists between the career opportunities that teens reported finding helpful and the opportunities to which they have access (Amgen Foundation and Change the Equation, 2016).
- Opportunity gap: Teens from low-income family have fewer opportunities for out-of-school time programs and career-related activities (Amgen Foundation and Change the Equation, 2016).
- Criteria for high-quality programs: Strong out-of-school time programs should address students' intellectual, academic, social, and emotional needs; attend to youth's interests, experiences, and cultures; and draw connections between formal, informal, and other settings (National Research Council, 2015).

High school involvement in Psychology

- Psychology Courses: 30% of graduating high school students earn credits in Psychology (Nord et al., 2011).
- Advanced Placement Exams: 293,350 students took the Psychology Advanced Placement exam in 2016. It was the second most popular STEM exam, following Calculus AB (The College Board, 2016). The number of students taking the Psychology AP has grown steadily in the last 10 years (College Board, 2016). The Psychology exam has the highest percentage of female students of any STEM exam (The College Board, 2013).

- International Baccalaureate Exams: Participation in the Psychology International Baccalaureate exams has also grown in the last decade. In 2005, the psychology exam had 97 candidates for the standard level exam and 203 for the higher level. In 2016, these numbers increased to 10,241 and 9,334, respectively (International Baccalaureate Organization, 2006 and International Baccalaureate Organization, 2016).
- Competitions: Many high school students are participating in Psychology through science fair competitions, including the American Psychological Association's research competition, the Intel International Science and Engineering Fair, the Junior Science and Humanities Symposium, Siemens We Can Change the World Challenge, the US Army's eCybermission Competition, Google Science Fair, THINK Scholars Program, and others.
- Online Resources: There are a number of online resources for high school students interested in Psychology, including the Online Psychology Laboratory from the American Psychological Association.

Barriers and challenges

Workshop participants split into groups and discussed challenges that could complicate the work of integrating teens in Living Laboratory. Four main themes emerged from this discussion:

1. Training teens: Concerns about training teens addressed a need for determining a set of pre-requisite knowledge for contributing to the research experience. There was some hesitation that, "you can't teach Psych 101 in three weeks." However, others argued you could have more than three weeks, or that a full Psych 101 was not actually a prerequisite for Living Laboratory participation.

   Possible next steps: Participants voiced interest in the National Living Laboratory creating a teen training toolbox, possibly including online modules. These resources would be available for local sites to use. Some voiced the concern that, even with such resources, there would need to be notable oversight at the local level.

2. Working with formal education: There was notable interest in working with formal educators to tie this program into existing curriculum. However, there are concerns that many Psychology teachers in high schools do not have backgrounds in the field, and that Psychology often sits within high schools' humanities departments.

   Possible next steps: Participants suggested reaching out not just to Psychology teachers but to science teachers in general. Many felt that National Living Laboratory's professional development materials could be valuable for formal educators, and that it could be valuable to promote these resources to this audience.

3. Addressing perceptions of Psychology: A number of people in the room noted that Psychology was a difficult field because there are wide misperceptions about what it entails. While Living Laboratory focuses primarily on Developmental and Cognitive Psychology, many people are more familiar with clinical aspects of the field.

   Possible next steps: There was wide consensus that a Living Laboratory program for teens should emphasize the fact that Psychology is a science. This should be clear in the recruitment process and should be embedded in the curriculum.

4. Finding capacity: The workshop participants were all very excited about the idea of working with teens in Living Laboratory, but many voiced concerns that they do not know how they would find capacity to do so. Many indicated that additional funding would be needed to support staff time for the project. For others, institutional policies and caps on staff size would limit the availability of staff.

   Possible next steps: Collaboration was seen as a possible approach for addressing some of these challenges; while an individual museum or a single research lab might not have the ability to carry out a teen program, partnerships allow for shared resources.

Teen outcomes

As shown in the table below, the discussion in this section of the meeting focused on two themes: skills teens could develop and other things that would motivate teens to participate.

Skills that teens could develop	*Additional teen motivators*
• Interpersonal skills: Including communication (especially with adults), working within a hierarchy, working with different ages, working within a team, and general social skills • College and career readiness skills: Including professional communication, content knowledge, Microsoft Office, critical thinking, brainstorming, and networking • General life skills: Including dependability, taking criticism, understanding boundaries, emotional intelligence, conflict resolution, adaptability, comfort with ambiguity, initiative, and comfort with failure • Self-improvement skills: Including self-efficacy, self-awareness, self-advocacy, self-confidence, and an understanding of one's strengths and interests	• Extrinsic motivators: Including money, parental enthusiasm, museum perks, school credit, t-shirts, or volunteer hours • Preparation for college and/or career: Including better understanding of the path to college, career awareness, resume-building, and gathering references • Intrinsic motivators: Including feeling important and having fun • Sense of self and sense of self within STEM: Including a sense of self as a scientist, STEM self-confidence, deeper understanding of what STEM is, identifying Psychology as a hard science, feeling like STEM is accessible • Interpersonal connections: In addition to the references mentioned above, this could include developing a network of like-minded peers, mentor relationships, and other social connections.

Professional outcomes

In this segment of the meeting, participants identified and discussed two main outcomes that could be valuable to professionals: (1) offering training that is not available in schools, and (2) offering college readiness. While these topics could seem to apply to youth outcomes as well, the professionals at the workshop felt that their ability to offer these services was a benefit to their organization. The summary of this conversation can be found in the table below.

Opportunities that are unavailable in schools
• Authentic research experience: Participation in the research process may give students a better understanding of the field than traditional lecture and textbook teaching approaches. • Resources for underserved youth: Many high schools are resource-scarce; having teens work with researchers and museums may provide access to materials and experiences that schools are unable to provide. • Exposure to careers: Living Laboratory's partnership model could give teens access to many different types of professionals within the informal learning and research communities.

Program logistics

This discussion was focused on three topics: recruitment, onboarding, and mentoring. There were many brainstormed ideas about these topics. The tables below summarize main points from these conversations.

Recruitment of teens
• Reach teens where they are. This may be social media. • Use the right partners. Schools and community organizations can help identify diverse students who might be interested in the program. • Try to recruit diverse mentors as well as diverse teens. • Find out institutional requirements for teen involvement early; there may be strict rules about eligibility and what teens are allowed to do. • Make sure you have physical space and staffing capacity to support the teens.

Onboarding teens
• Figure out how to get parental permission. • There will be HR paperwork. • Train teens about interacting with visitors as well as the overall mission and layout of the museum. • Teens should know about how the Living Laboratory model works. • Youth will need to learn about the research process, Psychology, and will need to complete human subjects training. • Include general training around professionalism, social media use, and public speaking. • Make sure you have physical space and staffing capacity to support the teens. • Teens need clearly defined roles, and they should know what's outside that role, and when to seek outside help.

Mentoring teens
• Mentoring experiences can be life-changing for both the mentor and mentee. • Mentors can help teens get their foot in the door in their field by making introductions, recommending resources, and serving as a reference. • Teens should ideally have mentors on both the museum and the research side. • Living Laboratory should review the literature around mentorship and clearly define the term within the context of these teen programs. • Mentors will need support and training in cultural competency, youth development, and legal aspects of mentorship to support underserved teens. • Peer-to-peer or near-peer mentoring can be valuable, since the mentor is often more relatable.

Program co-creation

During the last portion of the meeting, participants split into three groups to talk about possible modes of integrating teens into a Living Laboratory program.

A year-long opportunity with an intensive summer component

The first group discussed ways of setting up a year-long program with an intensive summer component. This group explored several approaches, identifying some advantages and challenges in each, as summarized below:

- Year-round with summer culmination: Youth could learn about Living Laboratory and the museum environment during the year (potentially Saturday workshops), and then could develop research questions and do their own, bite-sized research project over the summer. This would require notable mentorship from researchers to help teens plan manageable studies, but could be a highly valuable experience for teens.
- Summer intensive followed by year-round involvement: In an alternative approach, teens would build skills through intensive training over the summer, and then they could participate in shifts similar to other Living Laboratory researchers during the year.
- Multi-summer approach: There could be an intensive summer with training and planning, followed by a year of data collection, and then another intensive summer during which teens analyze and report on the data they collect. This approach introduces potential for previous cohorts of teens to serve as peer mentors in subsequent summers.
- Students leading their own research project: While there were questions about feasibility, this group was excited about the possibility of a teen working with a mentor to plan, build, and run all stages of a research project.
- Peer interactions: Members of this group shared a feeling that it would be valuable to have a cohort of teens so they can learn together, build a network, and build enthusiasm.
- Challenges: The group discussed the fact that slow scaffolding would be necessary, but potentially boring. Data collection may be the most fun part, but it can be hard to jump right to that, especially if the teens are developing the whole project themselves. It may also be difficult for teens to develop their own novel research questions.

A summer-only opportunity

One small group discussed what a summer-only program that integrated teens in Living Laboratory might look like. The points below highlight the themes from that conversation:

- Brief description: This type of program could be about 300 contact hours, spread out into 35-40 hours each week for eight weeks over a summer. It could engage underserved youth in contributing to authentic research experiences through the Living Laboratory model.
- Possible organizational benefits: One of the Living Laboratory Essential Elements is that research is an expected and predictable part of a museum visitor's experience. A teen program could strengthen Living Laboratory over the summer when many of the university students are gone and labs struggle to staff shifts. Sites might also benefit from reaching underserved populations and diversifying the workforce.
- Possible teen benefits: The program would be designed to foster both STEM and non-STEM skill development that would prepare high school students for college and career. Depending on the funding structure (see below), teens could be paid for their involvement.
- Mentoring: This group felt that it was important to develop a diverse mentoring ecosystem that would include other high school students, undergraduates, graduates, professors, educators, and others. A mentoring curriculum would need to be established, and the group felt consistent adherence to the curriculum would be important.
- Curriculum: The curriculum could be tiered, so each week is focused on a new aspect of the research process and increases teens' level of responsibility. Teens should have ownership of their work, even if it that does not mean designing and conducting a study from start to finish. For instance, teens could be fully in charge of one part of research, like recruitment or presenting a poster.
- Scale: Start small, with just a few students, and then build up!
- Funding: If teens are paid, as discussed previously, Museums and researchers could jointly apply for local grant funding. Some museums or labs might be able to pay students out of existing budgets. In some places, providing teens with salaries or stipends might not be feasible or desirable. Some participants had successful high school programs that required teens to pay to be part of a program. Other workshop attendees voiced concerns that requiring teens to pay could negatively impact the diversity of students who are able to participate.
- Potential challenges: Funding is a major challenge. Another possible barrier is that many researchers have pressure to 'publish or perish,' and may not have time to participate in a program like this. It might also be difficult for some sites to recruit diverse teens.

Partnering beyond museum staff and researchers

The third small group talked about ways to expand a Living Laboratory partnership beyond a museum and a research institution when including teens. Group members identified possible collaborators, approaches to partnership, teen curriculum, and credentialing opportunities. A summary of these discussions is below.

- Possible collaborators: A Living Laboratory partnership could also collaborate with:
  - *Formal education*: Local high schools have lots of teens, close by. Living Laboratory could be embedded in a Psychology curriculum, could help meet a community service requirement, or could be an independent study or internship.
  - *Businesses*: Many local businesses want to do outreach, and sometimes are willing to provide grant funding for local programs that offer STEM career development for diverse students. Some private research firms might also have research that could be applicable for Living Laboratory studies.
  - *Home school networks*: Home school students often have more flexible schedules than students in traditional high schools, so they could be at the museum during the week as well as evenings or weekends.
  - *Community organizations*: Afterschool programs, scouting troops, and other community groups often have regular contact with diverse high school students, and may be able to help with recruiting. Some might want to partner in developing curriculum, as many of these organizations have STEM initiatives.
- What partnership entails: The third party partner should have shared authority over goals such that the program is mutually beneficial. For it to be most valuable, the partner would bring something to the table that would take pressure off the museum or researcher. This might be staffing, space, recruiting assistance, funding, or something else.
- Curriculum: It would be ideal to have shared training modules created by National Living Laboratory. These could include topics like scientific research 101, multi-disciplinary study skills, how to participate in Living Laboratory, and other similar topics. A live, shared online instructor could be a valuable resource. The group agreed that research toys were a great way to initially get teens involved in Living Laboratory.
- Benefits to teens: High school students could benefit from the program in a variety of ways, possibly including earning a salary, gaining college or high school course credit, acting as an Advanced Placement or International Baccalaureate capstone project, or getting a badge or other credential from a community organization. Another incentive could be participation in a competition (possibly for the development of the best research toy), which might be sponsored by the third party partner.

Conclusion

The *NLL Workshop: High School Research Experiences in Living Laboratory* brought together diverse professionals who expressed interest in finding ways to integrate authentic research experiences for high school students into the Living Laboratory model. This document provides a summary of the meeting's proceedings, with the hope that professionals may benefit from the expertise that participants contributed to the day's conversations. Participants shared a wide range of experiences in working with high school students, illuminating many factors that can facilitate successful work, as well as strategies to address challenges that could arise. Finally, this document summarizes many opportunities for future work.

Recommendations coming out of this workshop include:

- Capitalize on interest: The attendees demonstrated notable enthusiasm for incorporating teens into the Living Laboratory model. This shows that the time is ripe for this work.
- Test the ideas: Participants brainstormed three approaches for involving teens in Living Laboratory. Sites should try these and other ideas to begin determining best practices.
- Recognize local diversity: Attendees represented a range of logistical constraints for their individual contexts. Each local partnership will look different, even if the community shares a set of common goals.
- Find partners with shared goals: Partners with agreed upon goals for a traditional Living Laboratory partnership may not share the same intentions for working with teens.
- Treat teens as professionals: Participants generally agreed that teens fit best in the Living Laboratory model as professionals rather than as members of the public.
- Emphasize mutual professional development: The Living Laboratory's Essential Elements that focus on developing professionals through shared learning experiences will be particularly important when working with teens.

The National Living Laboratory project team has already initiated efforts to pursue some of these opportunities, and hopes that other community members will find ways to explore avenues for future work that best suit their local interests.

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Living Laboratory
Developed at the Museum of Science, Boston

Appendix A: Essential Elements of Living Laboratory

Goals for Public Audiences

Positive Visitor Experience Facilitates Scientists' Interactions with Families

- Visitors contribute to the process of scientific discovery through participation in active studies
- Visitors engage in one-on-few educational interactions with scientists conducting the research
- Visitor education focuses on the process of science, increasing interest in and understanding of research "questions and methods" as well as "results"
- Studies occur in plain-view of the public, on the exhibit floor (not behind closed doors)
- Non-participant visitors talk with researchers and learn about on-going studies in ways similar to study participants
- On-site research is an expected and predictable part of the visitor experience

Goals for Professional Audiences

Mutual Professional Development

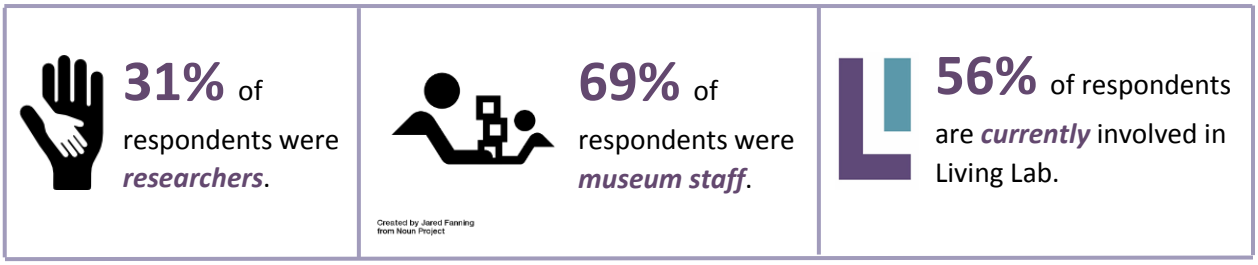
- Researchers receive training from museum staff in effective museum-style education techniques, improving researchers' communication skills with public audiences
- Museum educators gain direct access to current science that is relevant to their work with the public, improving educators' understanding of science and its potential application to their practice
- Museum educators and researchers communicate regularly, collaboratively monitoring the program to ensure scientific and educational goals are met, and that programmatic needs (e.g. logistical, financial) are fulfilled.

Appendix B: Community-wide Survey Findings about Teens & Living Laboratory®

In the fall of 2016, an online survey was distributed across the Living Laboratory community to gauge current interest in including high school students in Living Laboratory programs. A total of 458 Living Laboratory community members received the survey, and 98 people completed it, resulting in a 21.4% response rate. Analysis helped inform the *NLL Workshop: High School Research Experiences in Living Laboratory* agenda and potential future work with teenagers in Living Laboratory by answering the following evaluation questions:

1. In what ways are community members already working with high school students?
2. Why, if at all, are Living Laboratory community members interested in working with high school students?
3. What barriers might hinder sites' involvement of high school students?
4. What support could Living Laboratory provide to help sites work with high school students?

RESPONDENTS



IN WHAT WAYS ARE COMMUNITY MEMBERS ALREADY WORKING WITH HIGH SCHOOL STUDENTS?

Many community members had past experience working with high school students: almost all museum respondents had worked with them at their institutions, along with half of researcher respondents. Almost one-third of community members had also integrated these students into a Living Laboratory program. These experiences had been mostly positive (see Figure 1).[3] The students took on a range of roles and responsibilities, most often volunteering their time instead of filling an intern or staff position (see Figure 2).[4] Their responsibilities tended to be active, such as in helping with the study itself, interacting with the public through educational opportunities or participating in greetings, as opposed to passively observing or shadowing the researchers and museum staff (see Figure 3).[5] These findings illustrate how some research and museum organizations have successfully worked with high school students in the past, and that these organizations have already integrated students into active research, educational

[3] The survey included a "very negative" option, but no one selected it across the three audiences (museum staff, researchers or Living Lab participants).

[4] Respondents were invited to select all options that applied to their experiences, so may have had multiple responses.

[5] Respondents were invited to select all options that applied to their experiences, so may have had multiple responses.

opportunities and professional development. On the institutional side, there was a relatively even distribution of responsibility with respect to managing high school students: of 13 respondents, 4 credited this responsibility to museum staff, 5 to researchers, and 4 to both evenly.

Past experience with high school students

52% of research respondents have previously hosted high school students in their ***labs***	**98%** of museum respondents have previously hosted high school students at their ***museums***	**29%** of community members have previously integrated high school students into their ***Living Lab*** programs (n=52).

Figure 2: Overall, community members perceived their experiences with high school students as positive.

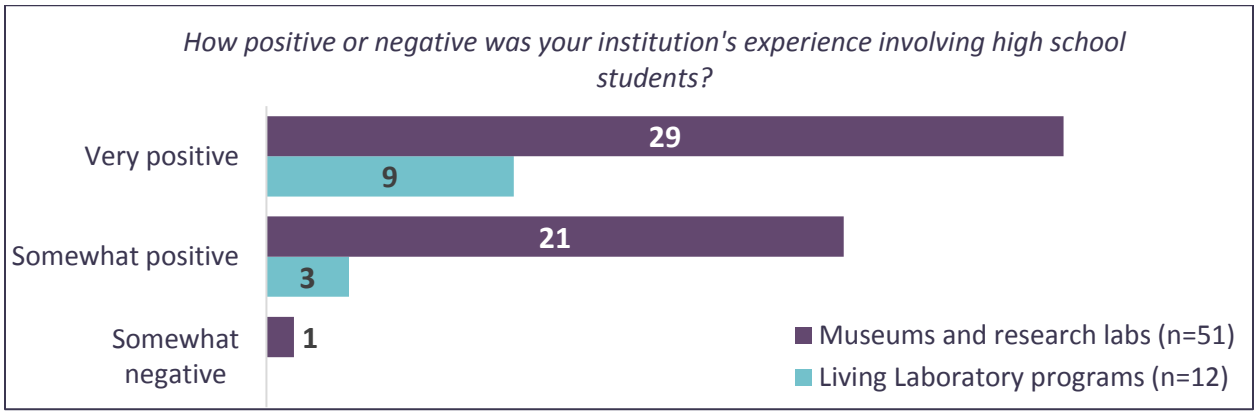


Figure 3: In the past, most high school students volunteered their time in museums and research labs.

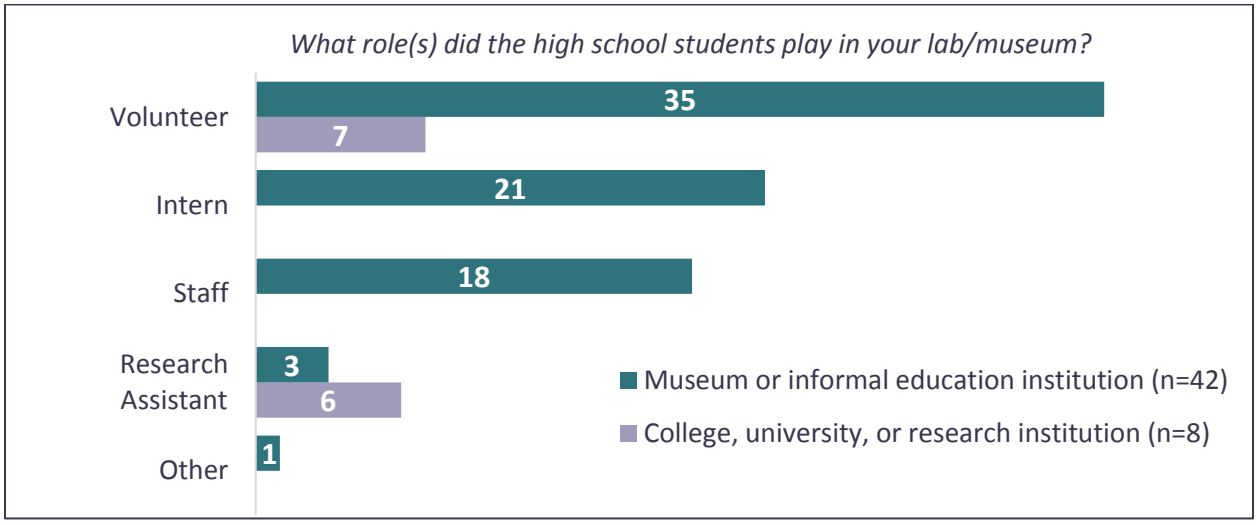
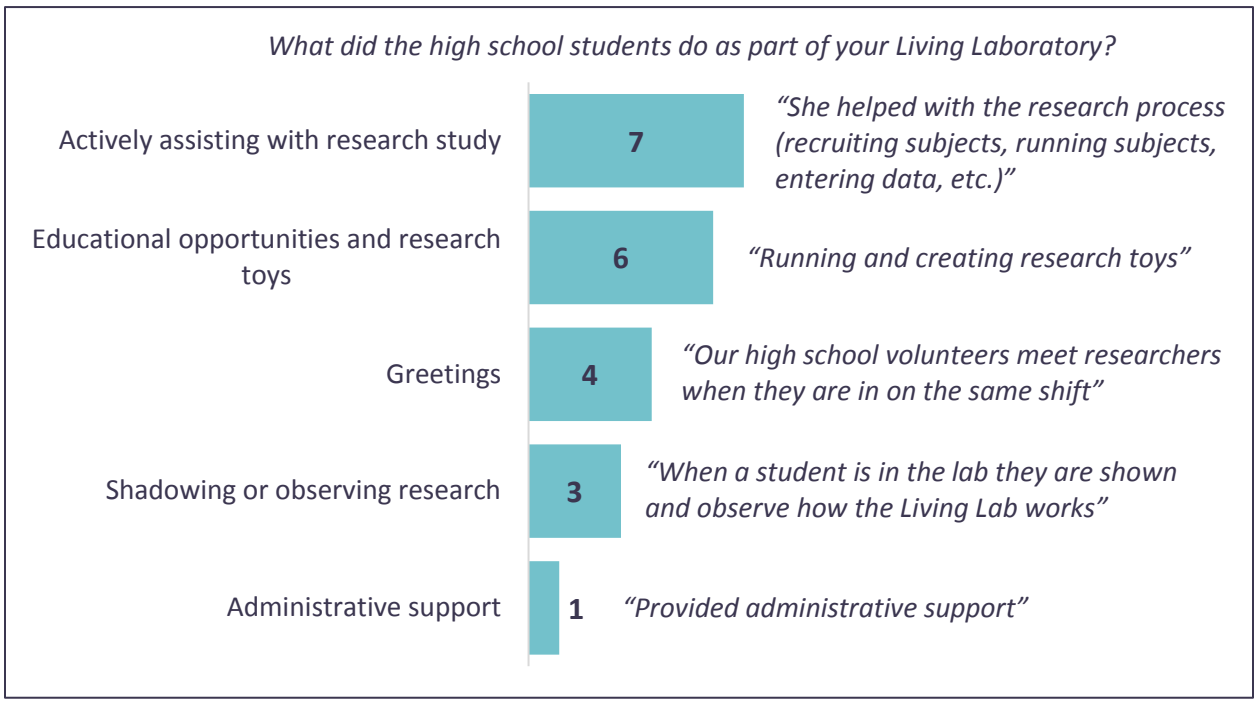


Figure 3: Currently, high school students are active contributors to Living Laboratory programs (n=13).



WHY ARE LIVING LAB COMMUNITY MEMBERS INTERESTED IN WORKING WITH HIGH SCHOOL STUDENTS?

The majority of respondents expressed at least some interest in incorporating high school students into Living Laboratory (see Figure 4). Professionals who expressed high interest did so because they perceived it as a positive educational and professional experience for students (n=12); as aligning with their institution's education and outreach goals (n=6); as a continuation of positive past experiences with high school students (n=4); and as an opportunity to develop mutually beneficial partnerships between museum and research organizations and students (n=4). Professionals who expressed reservations about working with these students shared concerns such as limited time and capacity at their institutions (n=10), recruiting "good fit" students (n=7), and institutional restrictions for working with minors (n=3).

Figure 4: Interest in integrating high school students in Living Laboratory exists within the community.

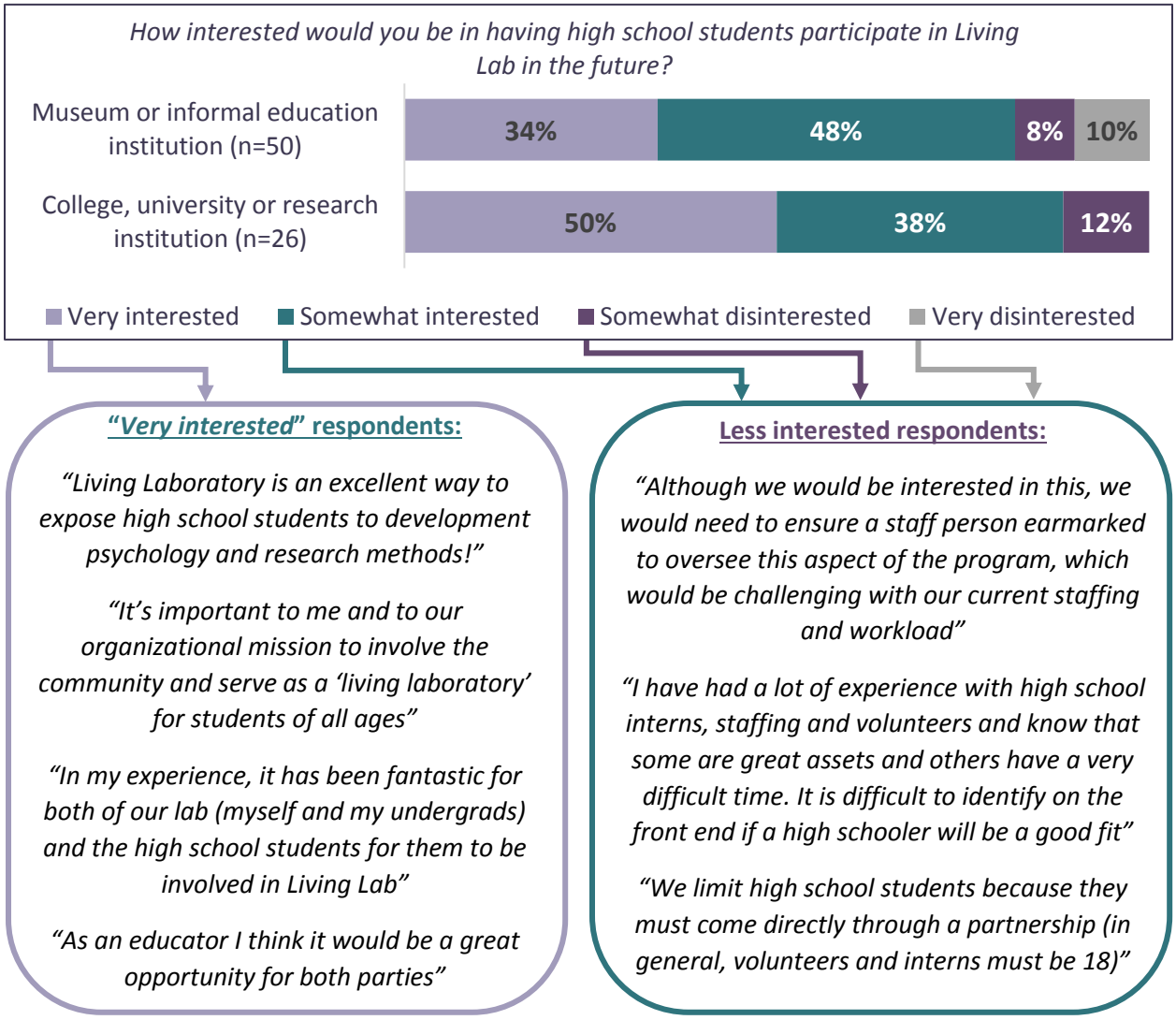
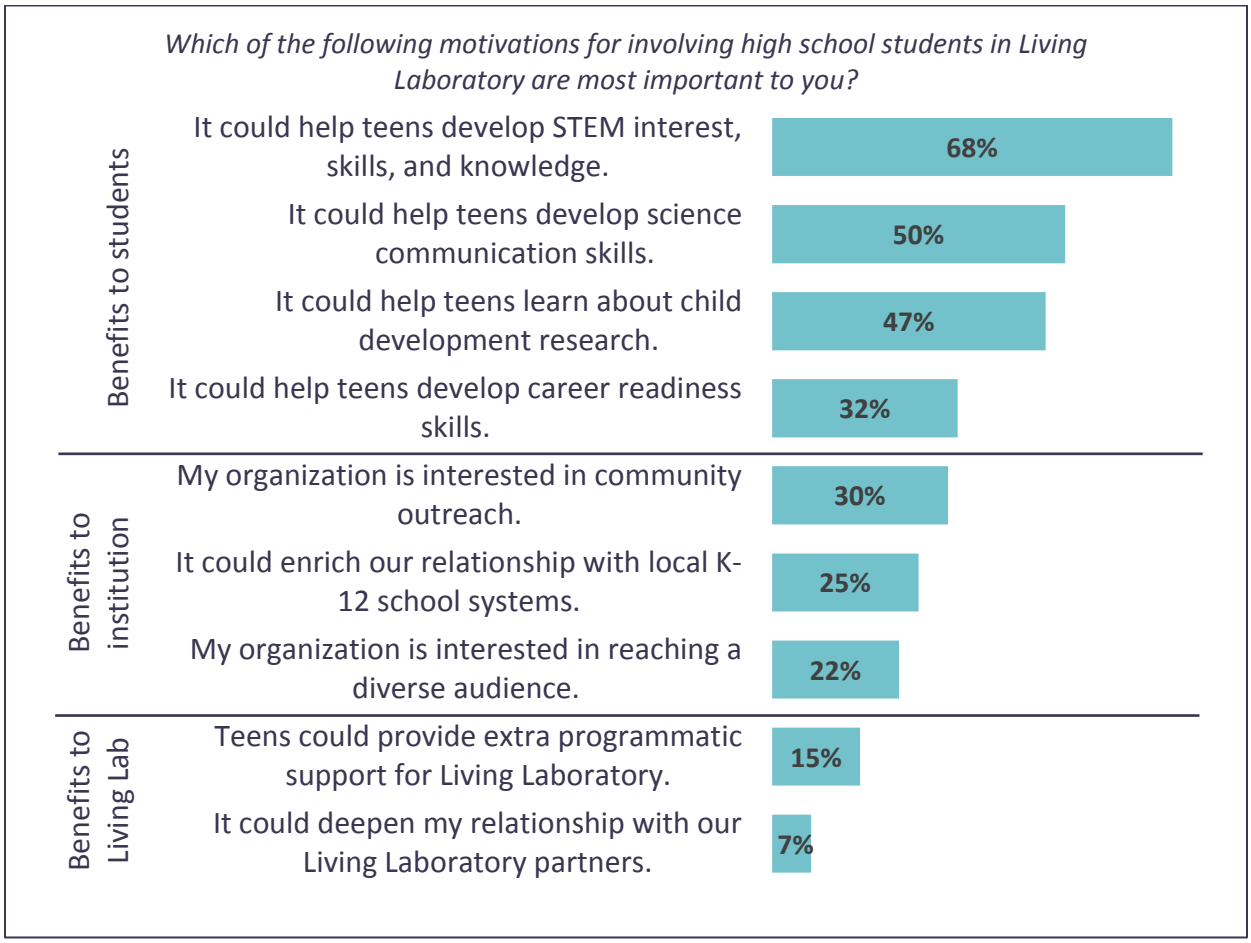


Figure 5, below, illustrates how community members rated a list of potential motivations for working with high school students. The four top motivations all emphasize the benefits to the teens, such as developing skills and learning about developmental psychology. These data suggest that respondents are motivated by the opportunity to extend Living Laboratory's mutual professional development philosophy (through which museum and research professionals learn from one another) to include high school students. Other motivations focus on the opportunity for community outreach generally as well as specific outreach to schools and diverse audiences. Less frequent motivators are the benefits to the local Living Laboratory programs, including teens offering programmatic support and developing deeper collaboration between the museum and research partners (see Figure 5).[6]

[6] Respondents were invited to select up to three motivations that resonated most with them. Therefore, one respondent's answer may be counted up to three times. "Other" responses not included.

Figure 5: Professionals are motivated by the perceived benefits to high school students (n=60).

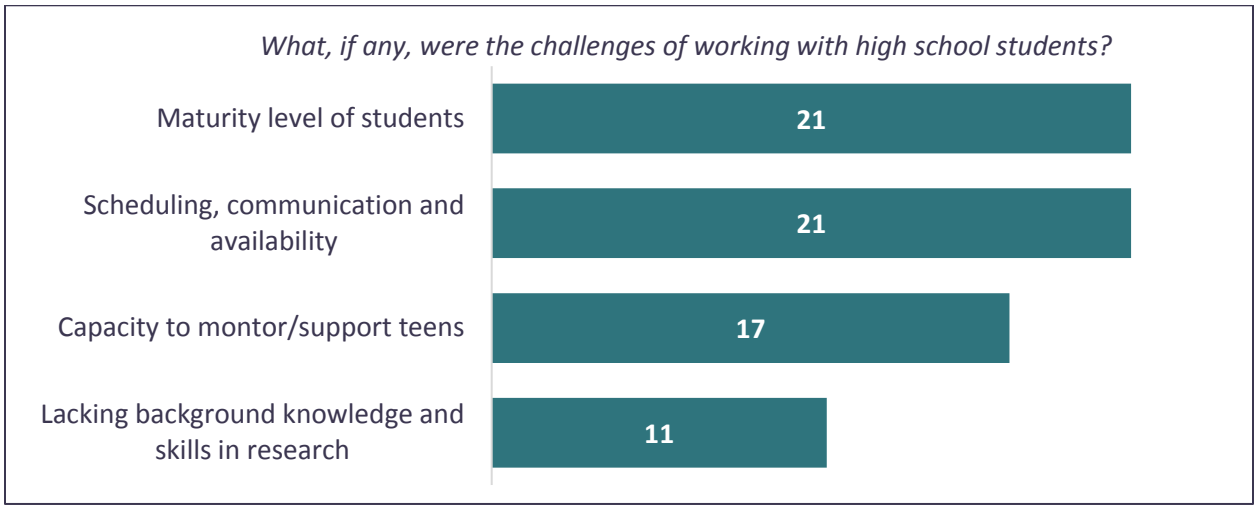


WHAT BARRIERS MIGHT HINDER SITES' INVOLVEMENT OF HIGH SCHOOL STUDENTS?

The challenges and obstacles of past experiences can help Living Laboratory leadership develop a strong plan to successfully implement this work. Respondents shared past challenges in working with high school students as well as their concerns about potentially integrating them into Living Laboratory. In the figure below, survey respondents who had worked with high school students in a research lab, museum, or Living Laboratory shared that underdeveloped knowledge and maturity levels, as well as availability, are challenges directly related to the students themselves, while professionals' limited capacity to allocate enough resources, time, and mentoring to teens is an obstacle on the part of the institution (see **Error! Reference source not found.**6).[7]

[7] Both groups that have worked with high school students in Living Laboratory and within their institution are represented in this chart, though they were questions that were slightly different in language. The former responded to "*What, if any, were the challenges of incorporating high school students in Living Laboratory?*", while the latter answered, "*What, if any, were the challenges of working with high school students?*" The chart above portrays the top four more frequent challenges cited by both groups, combined. When separated, Living Laboratory professionals' top challenges were scheduling, maturity levels, high

Figure 6: Previous challenges include teens lacking mental readiness and time to work with museum and research institutions (n=49).



As is often the case, the most prevalent concerns about potential high school student integration revolved around money and time. Respondents also predicted that recruiting and mentoring students may be somewhat difficult (see Figure 7).[8] Additionally, they reemphasized these concerns in their responses to the open-ended questions (see Table 1). These responses frequently addressed institutional restrictions, while such obstacles were rated as less challenging in the close-ended data. This suggests that while institutional obstacles may not be a barrier to some, for those for whom it is, it may be a major barrier. Finally, three museum respondents worried that high school students may not be able to do "good science," in that they may not have practice or training in critical components such as confidentiality and bias avoidance, which could jeopardize the data. These comments also included concerns about the perception of research performed by these students, in that parents or members of the community may devalue its validity because of the young assistants.

turnover, and lack of background knowledge, while non Living Laboratory respondents cited maturity levels, the institution's capacity to train and mentor, scheduling and lack of background knowledge as the biggest obstacles in working with teens.

[8] For clarity, only values at 9% or higher are identified.

Figure 7: Time and money are the main foreseen challenges of high school student integration.

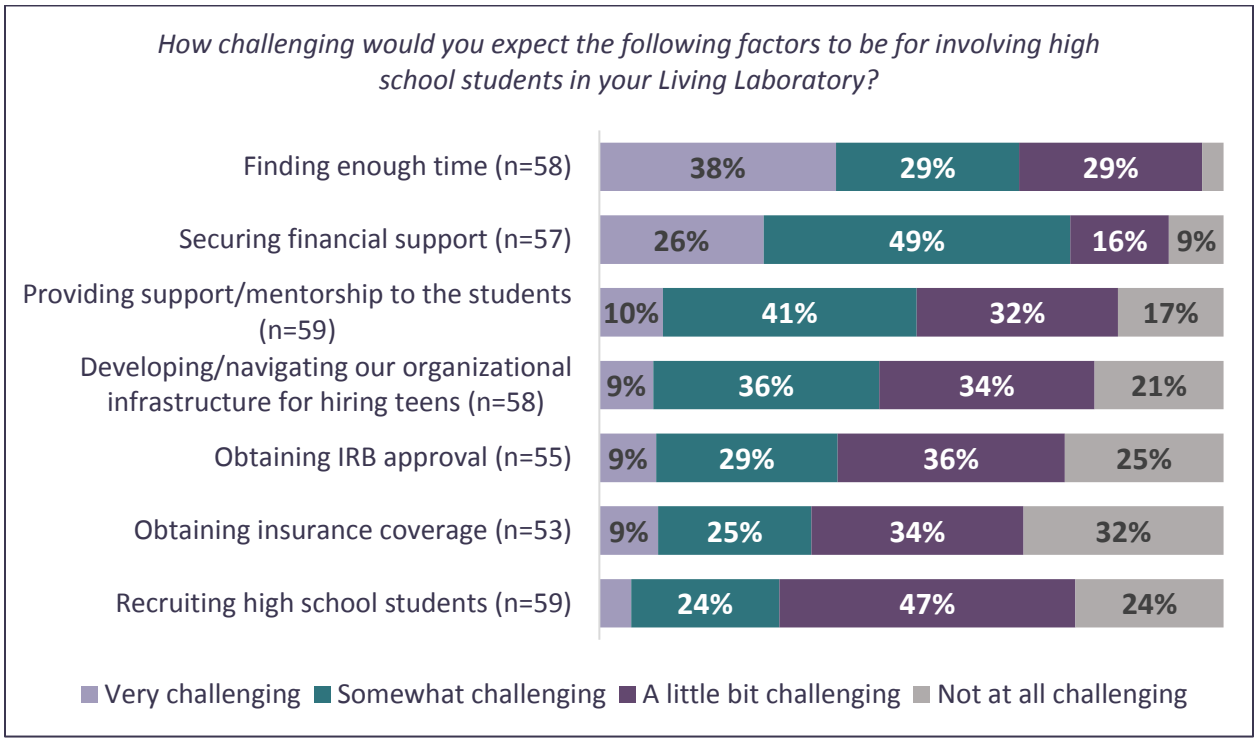


Table 1: Potential challenges of integrating high school students, free response (n=19)

What other factors, if any, would you be concerned about if you were going to incorporate high school students in your Living Laboratory?		
Code	**Count**	**Quote**
Capacity to mentor/support teens	**6**	*"I would want them to have the support they need to feel confident to explain the research to care-giving adults"*
Institutional restrictions	**4**	*"I have concerns about my ability to get institutional approval"*
Students jeopardizing the validity of research	**3**	*"Ensuring that the students don't communicate results with others"*
Recruitment issues	**3**	*"I haven't yet been faced with the challenge of outreach to schools [and] students"*
Maturity level of students	**2**	*"My main concern would be the level of maturity [and] commitment"*
Compensation	**1**	*"Would they be paid, or get some kind of credit?"*

WHAT SUPPORT COULD LIVING LAB PROVIDE TO HELP SITES WORK WITH HIGH SCHOOL STUDENTS?

In both close and open-ended responses, community members strongly desire monetary support from leadership, as well as resources in training, evaluation and recruitment (see Figure 8 and

Table 2).[9] However, they also expect flexible resources that are adaptable to various settings, as they called for resources that "are useful across different types of sites" and assigned lower ratings for structured curricula. Furthermore, according to Figure 8, these implementation resources are more desired than networking opportunities and direct leadership communication. This suggests that sites may feel confident in integrating high school students autonomously and with limited consultation if they have access to the proper resources.

Figure 8: Community members most value money and resources from leadership.

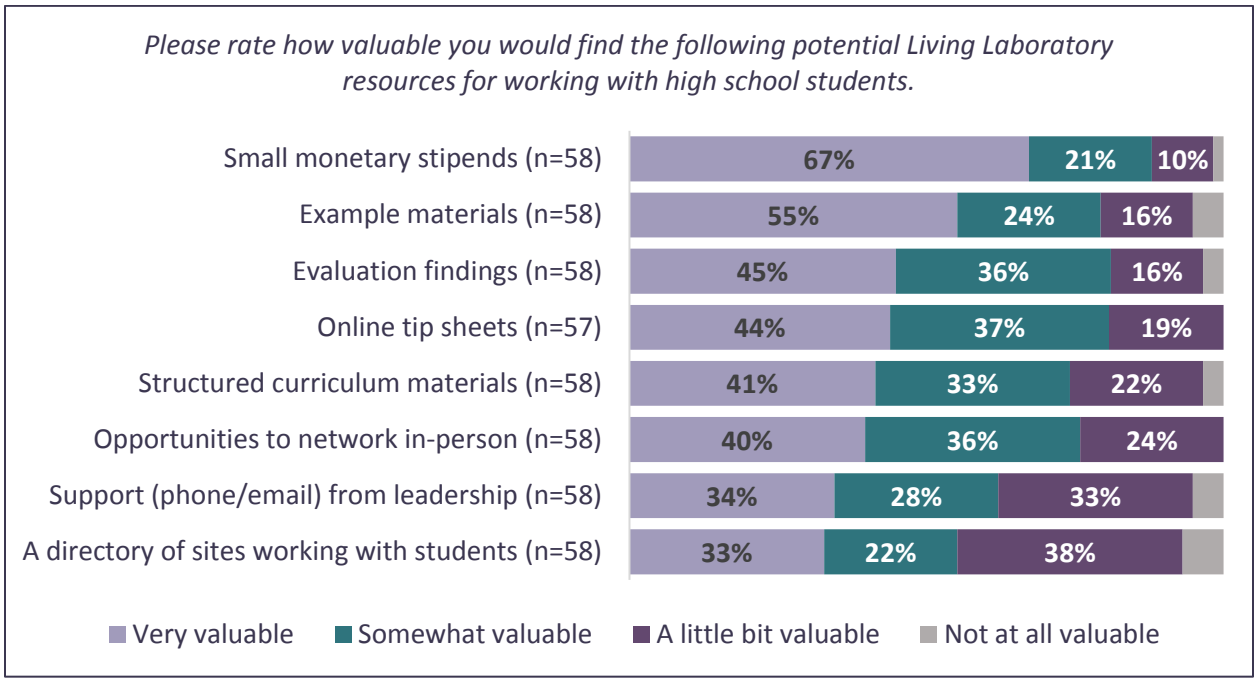


Table 2: Other leadership resources suggested by community members, free response (n=7)

What other resources, if any, could Living Laboratory provide that would help you incorporate high school students at your site?		
Code	**Count**	**Quote**
Recruitment tools	**3**	*"Tested methods for recruiting minority [and] ethnic populations"*
Training support and resources	**2**	*"Thorough training materials that would streamline the training process"*
Group support for participating students	**1**	*"[Living Laboratory] could bring together the [high school] students who are involved in the program to better understand their needs, provide group support and communicate their concerns to the PI's"*
Variety of implementation tools	**1**	*"I think that it will be crucial to involve folks at both larger and smaller museums so that the materials are useful across different types of sites"*

[9] For clarity, only values at 9% or higher are identified.

Appendix C: *National Living Laboratory Workshop: High School Research Experiences in Living Laboratory* Attendee List

The following table lists the workshop attendees, their affiliated institutions, and their professional positions.

Name	Position	Institution
Katie Baur	Coordinator, National Living Laboratory	Museum of Science, Boston
Jillian Beans	Youth Program Coordinator	Connecticut Science Center
Lorrie Beaumont	Director of Education	Ann Arbor Hands-On Museum
Marta Biarnes	Professional Development Associate, National Living Laboratory	Museum of Science, Boston
Peter Blake	Assistant Professor of Psychology	Boston University
Jen Bush	Executive Director	Delaware Children's Museum
Emily Leary Chesnes	Assistant Director for Precollege and Undergraduate Education	American Psychological Association
Jennifer Clegg	Postdoctoral Research Associate	Boston University
Debbie Cockerham	Managing Director, Research and Learning Center	Fort Worth Museum of Science and History
Megan Dempsey	Public Programs Coordinator	Connecticut Science Center
Annie Douglass	Senior Educator, Science Playground	Oregon Museum of Science and Industry
Margaret Echelbarger	Graduate Student	University of Michigan – Ann Arbor
Rachel Fyler	Education Associate	Museum of Science, Boston
Jacquie Genovesi	Vice President, Education	Academy of Natural Sciences of Drexel University
Alice Gonglewski	Programs and Learning Manager	Please Touch Museum
Anna R. Greenswag	Senior Program Manager for RISE & AIM	Boston University
Preeti Gupta	Director of Youth Learning and Research	American Museum of Natural History
Brittany Jeye	Graduate Student	Boston College
Deb Johnson	Senior Director of Education and Exhibits	Children's Museum of Southern Minnesota
Kia Karlen	Director of Education	Madison Children's Museum
Melissa Kibbe	Assistant Professor of Psychology	Boston University
Becki Kipling	Program Manager, Discovery Center	Museum of Science, Boston
Denise LeBlanc	Director of Learning Experiences	The Discovery Museums
Dale McCreedy	Vice President of Audience and Community Engagement	Discovery Center at Murfree Spring
Shannon Mersand	School Media Specialist	Yorktown High School
Paul Muentener	Assistant Professor of Psychology	Tufts University
Erik Nilsen	Associate Professor of Psychology	Lewis and Clark College
Jenna Petrosino	Education Manager	Children's Museum of Richmond
Sarah Pfeifle	Research and Evaluation Assistant	Museum of Science, Boston
Stacey Prinzing	Assistant Director or Education	Maryland Science Center

Nathaniel Rabb	Lab Manager, Arts and Mind Lab	Boston College
Kristin Shutts	Associate Professor of Psychology	University of Wisconsin-Madison
Katie Todd	Research and Evaluation Associate	Museum of Science, Boston
Jenny Wang	Graduate Student	Johns Hopkins University
Ellen Winner	Professor of Psychology	Boston College
Jenn Zosh	Assistant Professor of Psychology	Penn State University – Brandywine