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MESA Mathematics Engineering Science Achievement
OREGON

Design for the Other 90%

Student Perceptions of Oregon MESA's Invention Curricula

February 2015

About Education Northwest

Founded as a nonprofit corporation in 1966, Education Northwest builds capacity in schools, families, and communities through applied research and development.

This is a final evaluation report of Oregon MESA's (Mathematics, Engineering, Science Achievement) work on innovation in education for diverse and underserved students, supported by a Lemelson Foundation grant. The report summarizes findings from surveys and focus groups conducted to evaluate student response to MESA's invention curricula.

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Suggested Citation

Greenberg Motamedi, J. (2015). *Design for the other 90%: Student perceptions of Oregon MESA's invention curricula.* Portland, OR: Education Northwest.

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Executive Summary

Oregon Mathematics, Engineering, Science Achievement (MESA), with the aid of a grant from the Lemelson Foundation, has focused its educational work with underrepresented minority students from middle and high school on inventions that address key problems in developing countries: sustainable lighting, water transportation, water filtration, and prosthetics.

The MESA *Design for the Other 90%* project created four curricular units in which students collaborate to design, build, evaluate, and present a usable product designed for a particular client. In this report, we examine the perceptions and self-reported learning of MESA students who participated in these curricula during the 2012/13 and 2013/14 school years. The findings for each of MESA's goals of this project are summarized below.

MESA seeks to increase underrepresented students' access to, and interest in, science, technology, engineering, and mathematics.

Minority groups, including nearly a third Latino students, made up a majority of the students who participated in the surveys and focus groups. Student responses to questions about the curricula and project did not vary much by ethnicity or race.

Girls, another underrepresented group in science, technology, engineering, and mathematics (STEM) were well represented among MESA students. Girls showed greater growth in some skills but reported lower levels of self-efficacy as inventors compared to boys. We suggest that this difference be explored more fully in future evaluation work using focus groups.

MESA teaches a set of 11 skills through the invention curricula.

Did students report growth in these skills? Overall, students reported significant growth in all eleven skills and most students coming in with low skill levels reported growth over the course of the school year. However, few students with high initial skills reported growth.

We found significant differences between school years, where growth was greater in 2013/14 than in 2012/13 in five skills—using the engineering design process (EDP), planning, choosing solutions, building products, and testing products.

We also found significant differences in how groups of students reported skill growth. Specifically,

- Girls reported more growth than boys in three skills—planning, choosing good solutions to design problems, and presenting products.
- Black and Latino students were more likely to report improvement in designing products.
- Veteran MESA students who participated in MESA for more than one year reported significantly more growth in presenting than newcomer students.

Some student skill growth was not visible in the survey data. However, in focus groups, students identified teamwork, problem-solving, and decision-making as areas of high growth. Nearly all students in focus groups said that their ability to work, communicate, and problem-solve as a group had improved because they had to work together while engaged in MESA. Based on survey responses alone, these skills did not stand out, which suggests that the survey instruments may need to be retooled and that the evaluation team should continue to conduct focus groups among students.

MESA builds students' self-efficacy as inventors and designers.

Nearly all students agreed that inventors help people, and most students felt that they would use invention skills as an adult to help them earn a living. About two-thirds of students said they could envision themselves as an inventor or felt that they would make a great inventor. However, boys were significantly more likely than girls to see themselves as an inventor or to feel that they would make a great inventor. We suggest that this difference be explored more fully in future evaluation work using focus groups.

MESA wants its students to tackle real-life problems faced by real people and to develop a sense of global citizenship.

How do students report that the curricula affect their sense of global citizenship and interest in other people? Most students agreed that working on their MESA project affected their interest in learning about and helping other people, encouraged them to conserve energy, and got them to think about new ways to promote sustainability. Students reported a significant growth of interest in helping and understanding other people, and in comparing their lives to others. This growth was greatest among students who initially were the least interested in other people.

Two-thirds of the students completed their project and built an invention. However, students who attended MESA during school hours were more likely to have built, tested, redesigned, and presented their invention than those who attended MESA after school.

Finally, students were unequivocally positive about their experiences in MESA, and most agreed that MESA was a fun place to learn, involved them with learning, and was a safe place for them to be themselves. Students who attended MESA after school and veteran MESA participants were more likely to see MESA as a fun place to learn and a safe place for them to be themselves.

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Design for the Other 90%

Much of the creativity and effort of scientists, engineers, and inventors is directed at improving the comfort or efficiency of technology for affluent people from the wealthiest countries. In addition, many of the scientists, engineers, and inventors are themselves affluent people from the wealthiest countries.

That is why Oregon Mathematics, Engineering, Science Achievement (MESA), with the aid of a grant from the Lemelson Foundation, decided to focus its educational work with underrepresented minority students from middle and high school on inventions that address key problems in developing countries: sustainable lighting, water transportation, water filtration, and prosthetics.

The MESA *Design for the Other 90%* project created four curricular units in which students collaborated to design, build, evaluate, and present a usable product designed for a particular client. For example, some students working on the water transportation curriculum designed and built water carriers that were physically and culturally appropriate for children in post-earthquake Haiti.

In this report, we examine the perceptions and self-reported learning of students who participated in MESA's *Design for the Other 90%* curricula in Oregon and California schools during the 2012/13 and 2013/14 school year. All of these students participated in their school's MESA chapter, with teachers who had received professional development from MESA on using the invention curricula. Students responded to surveys (N=418) and focus groups (N=60). To facilitate statistical analysis, we combined survey results from 2012/13 and 2013/14.[1] For each item on the survey we tested to see whether there were statistically significant ($p \leq .05$) differences between years. Unless specifically indicated in the text, however, there were no significant differences in student responses over the two years.

The findings for this project are detailed below, and full survey results and focus group protocols can be found in the appendix to this report.

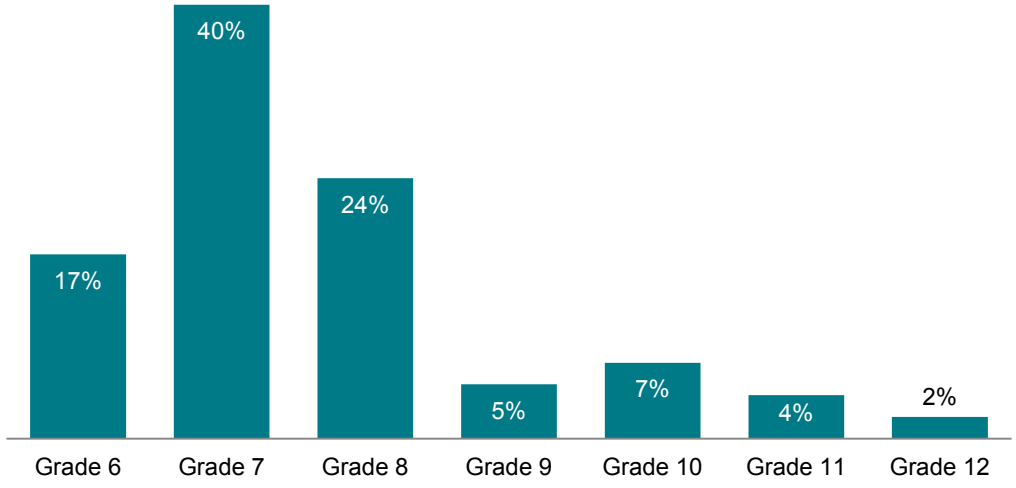
MESA attracted underrepresented minority students and girls.

MESA seeks to increase underrepresented students' access to, and interest in, science, technology, engineering, and mathematics (STEM). Minority students made up more than half the students who responded to the survey, similar, presumably, to those participating in Oregon MESA chapters. Girls, another underrepresented group in STEM education, made up

[1] Regardless of year, students responded to identical questions. A total of 202 students responded to the MESA Student Survey between February 22 and April 26, 2013 and 216 students responded to the survey between January 14 and February 18, 2014.

slightly less than half (47%) of survey participants. Most participants (81%) attended middle school, with 40 percent in seventh grade (Figure 1).

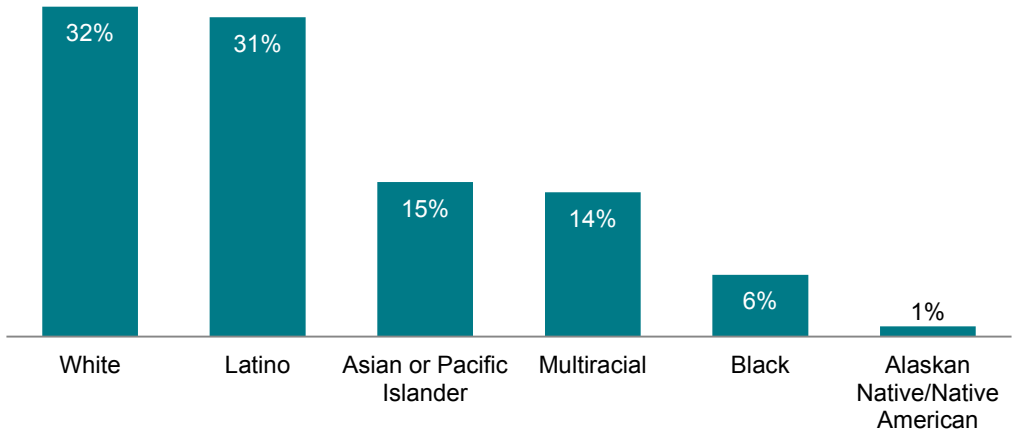
Figure 1
Most MESA participants were in middle school.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Two-thirds (67%) of MESA participants were minority students. Just under a third of the participants were Latino (31%) students. There were fewer Asian (15%) or multiracial (14%) students, while Black (6%) and Native American students (1%) composed a small minority (Figure 2).

Figure 2
Two-thirds of MESA participants were minority students.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Most participants were newcomers to MESA. Nearly three-quarters of MESA students (71%) reported in surveys that this was their first year of participation in MESA. Almost a quarter of students (24%) reported that this was their second year participating. A small group (5%) had participated in MESA for three or more years.

Student responses differed by demographics and experience.

Students clustered into several statistically distinct groups, defined by demographics (race/ethnicity and gender), when they attended MESA (during school or after school),[2] and how long they had participated in MESA (veteran or newcomer).[3] For each item on the survey we tested for and reported statistically significant ($p \leq .05$) differences. For example, on all survey items, we tested if girls and boys responded to the question differently.

Overall, we found two sets of questions that showed gendered differences, and one area in which students of different race or ethnicity responded differently. Specifically, we found that

- Girls showed more growth than boys in planning, choosing good solutions to design problems, and presenting products.
- Girls were less likely than boys to see themselves as an inventor or feel that they would make a great inventor.
- Black and Latino students showed greater improvement than other groups in designing products.

We also found three sets of questions that showed significantly different responses between students who participated in MESA during school hours (41%) and those to those who participated after school (59%). We found that students who attended MESA during school hours:

- Were more likely to have completed the last four steps of the project than than students who attended MESA after school
- Were more likely to show a positive change in "helping people who are poorer than you" than students who attended MESA after school
- Were less likely to see MESA as a fun place to learn and a safe place for them to be themselves than students who attended MESA after school

Finally, we compared MESA newcomers (first-year MESA students) to veteran MESA participants who had participated for two or more years, and found that veteran MESA students:

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[2] Only George Middle School had a MESA chapter that met during the school day. Consequently, we are comparing George to all the other MESA schools. We found no other differences by school.

[3] Differences by grade level, school, and whether someone in the student's family had gone to college were not statistically significant, and are not reported.

- Showed higher growth in presenting than newcomers
- Were more likely to report that MESA was fun place to learn, got them involved in learning, was a safe place, and was important to them

There was a considerable overlap between when students participated in MESA and how long they had participated. Many (81%) of the students who attended MESA during school hours were first time MESA participants, while a smaller percentage of the students (63%) in afterschool programs were newcomers.

Did Students Learn Invention Skills?

The invention curricula teach a set of 11 invention skills, which range from using the engineering design process (EDP) to teamwork and thinking creatively. In surveys, students self-reported statistically significant growth in all skills. In focus groups, they identified teamwork, decision-making, and problem-solving as the most important lessons they learned.

Students had significant growth in all skills.

On surveys, we asked students to rate how good their skills were before participating in MESA and then how strong they were after having participated. Students reported significant growth in all skills, with a half to a third of students (depending on which skill we asked about) reporting in surveys that their skills grew over the course of a school year.

We found that students who reported low initial skills were much more likely to report skill growth than those with higher initial skills. We also found important differences between groups in the amount of reported skill growth. Finally, we found significant differences in skill growth between 2012/13 and 2013/14.

Growth reported by students was statistically significant in all skills, with a third to a half of students reported growth in specific skill areas. In addition, a higher percentage of students reported positive change in 2014 than in 2013 in five skills—using the EDP, planning, choosing solutions, building products, and testing products (Table 1).

We cannot say why students rated their growth higher in 2014 than in 2013. For example, it could mean that the teachers were more effective in teaching these skills in 2014; however, it could also mean that the students participating in MESA in 2014 were more optimistic about their skill growth than those participating in 2013. We hope to explore these differences in future evaluation work.

How did we measure growth?

We asked students to rate their invention skills retrospectively . That is, we asked them to think back to a time before participating in MESA and rate their skills, and then rate their current skills after participation.

This method has some advantages over the traditional pre-test and post-test method as it allows it to be "clear where the workshop has succeeded or where work remains to be done," with decreased risk of participants starting too high with no room for improvement (Lamb & Tschillard, 2005).

However, one limitation to this method is that data are self-reported with no comparison group, which means we cannot know for sure that the growth reported was authentic.

Students responded to questions, rating their skills before and after completing the curriculum's project on a four-point rubric ranging from "bad news" to "I'm great." '

We also asked students to rate their interest in learning about other people on a four-point rubric and computed a retrospective gain score.

Table 1
Student growth was statistically significant in all skills.

Skill	Percent reporting positive change		
	2012/13	2013/14	Combined
Using the engineering design process*	50%	65%	58%
Planning*	39%	55%	47%
Choosing good solutions to design problems*	37%	56%	47%
Building products*	31%	51%	41%
Testing products*	26%	46%	36%
Designing products	40%	47%	44%
Presenting products	41%	48%	44%
Solving problems	35%	39%	37%
Communicating clearly	34%	34%	34%
Working on teams	20%	32%	26%
Thinking creatively	31%	31%	31%

* Statistically significant difference between 2013 and 2014.
Note: All skills showed statistically significant growth between pre and post responses in 2013 and 2014.
Source: MESA Student Surveys from 2012/13, 2013/14, and combined surveys from 2012/13 and 2013/14

Students' ratings of their skills had a strong ceiling effect.

Students who rated their initial proficiency in skill as "Good" or "Great" were significantly less likely to report a positive change in that skill after participating in MESA. Across all skills, less than a quarter (23%) of the students who rated their initial proficiency in skills as "Good" or "Great" reported positive change. In contrast, nearly three-quarters (73%) of the students who rated their initial proficiency in skills as "Bad News" or "Could be Better" reported positive change (table 2).

Table 2
Students who initially rated skills higher were less likely to report improvement.

	Percent reporting positive change	
	Initial skills are "Good" or "Great"	Initial skills are "Bad News" or "Could be Better"
Planning	29%	82%
Using the engineering design process	26%	79%
Choosing good solutions to design problem	28%	80%
Working on teams	16%	69%
Designing products	24%	73%
Building products	20%	76%
Testing products	22%	76%
Presenting products	16%	65%
Solving problems	24%	75%
Thinking creatively	21%	63%
Communicating clearly	23%	65%

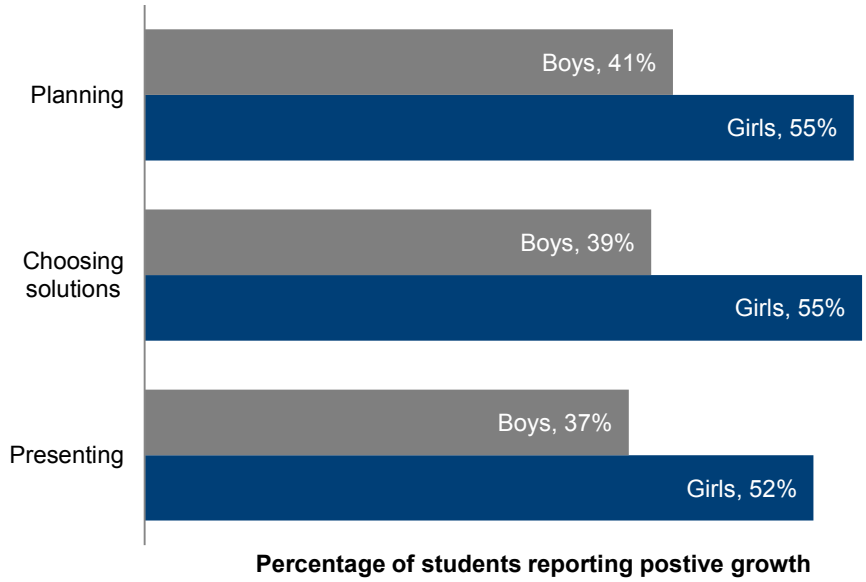
Note: All skills showed statistically significant differences between groups and the percent reporting positive change
Source: Combined MESA Student Surveys from 2012/13 and 2013/14

It is unclear why there is a ceiling effect. For example, it could mean that the survey does not adequately capture growth among advanced students. Alternatively, it could mean that MESA advisors struggle to differentiate instruction between students of different skill levels. In any case, the evaluation team plans to examine this question in the future by speaking with MESA students and advisors, and retooling the survey.

Girls, veteran MESA students, Black and Latino students reported greater improvement in some skills than their peers.

Girls reported more skill growth than boys in three areas: planning, choosing good solutions to design problems, and presenting products (Figure 3). This growth was reflected by the girls' higher self-reported skill scores *after* participating in MESA, and not from students' self-reported initial skill level, which showed no significant differences between genders.

Figure 3
Girls reported growth more often than boys in three areas.



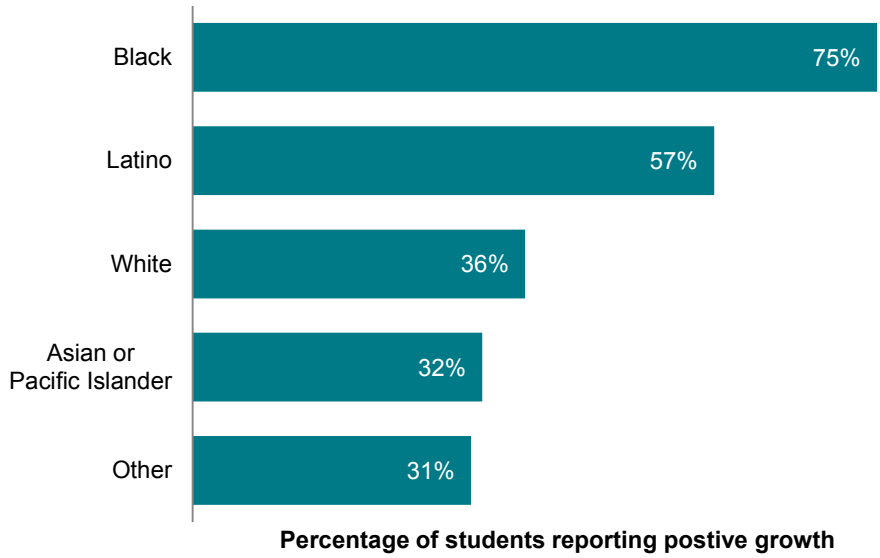
Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Veteran MESA students, who participated in MESA for two or more years, showed significantly more growth in presenting than newcomer students (56% of veterans compared to 40% of newcomers). There was no difference in their self-reported initial skill levels.

Finally, Black and Latino students reported greater improvement in designing products than other racial or ethnic groups[4] (Figure 4). There were no differences in the initial skills that Black or Latino students reported compared to what was reported by other groups.

[4] Because of the small number, we collapsed American Indian and Alaska Native students into "Other."

Figure 4
Black and Latino students reported more growth in designing products than their peers.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Students spoke about teamwork, decision-making, and problem-solving.

In focus groups, students said that MESA taught them about teamwork, decision-making, and problem-solving. However, these were not skills which stood out in the survey responses. Only a small group of students reported, on surveys, that their skills grew in working on teams (26%) or solving problems (37%). The survey did not ask them to report on decision-making. It is unclear why there was a difference between how students responded in surveys and in the focus groups. The survey questions may not have been clear enough, or perhaps students find it easier to discuss growth in person, in a group. In any case, retooling the survey and focus group protocols will be the evaluation team's next step.

Students learned about teamwork.

In focus groups, students told us that the most important lesson they learned in MESA was how to work as a team. Teamwork was not a lesson that stood out in survey responses, but was identified by students in the focus groups we conducted.[5] For example, one student said that "the most important thing I learned in MESA is how to work together, and how to help each other."

[5] To test if the focus group responses around teamwork were linked to the sample of students and the schools we visited, we compared responses from the focus group schools in the same year to all the other schools, and found no differences around teamwork. That is, the schools we conducted focus groups in did not show a larger growth in teamwork than other MESA schools.

The teamwork skills that students learned in MESA were different from the partnering skills they learned during school.

> *Partner-working in class is pretty easy, because you just read the question, have a short conversation, and write up what you talked about. But teamwork is different because you all have to think of an idea that works well together, and you could be working on different parts, but they have to work together, so you have to plan on that and build the same thing. (MESA student)*

A benefit to working in teams is that "you don't have to do it all yourself." One boy said,

> *We couldn't have done it alone. Everybody just came up with ideas—one person each had an idea—and then decide with a range of options. (MESA student)*

Students said that they were also able to work much more efficiently in teams.

> *Instead of working on one thing, we split it up and did two things at one time. It was a lot faster, and a lot more fun. It would be really hard to do that all by yourself. (MESA student)*

MESA students also said that working in teams helped them "pull through after a mistake" by having other people help problem-solve with "different opinions." However, this meant that partners needed to "give in and admit that their idea wasn't the best." One girl told us that:

> *You need to learn that your opinion isn't always the best one, and that if someone out does you or shows that your idea is wrong, you aren't a failure. You just need to accept that. You could argue forever if you don't learn to do that. (MESA Student)*

Boys and girls described the decision-making process differently.

Most of the students agreed that the hardest part of working together was the decision-making process. However, boys and girls described decision-making differently. Boys described coming to a decision as a "compromise" in which they individually let go of their ideas, while girls described that it was about careful explanation and "communication."

Boys told us that they "don't always agree" and that coming to a compromise was the most difficult part of working in a team.

> *Learning how to compromise was the hardest part, because we all have different ideas and we had to put it together and work as a group. (MESA student)*

To overcome this, boys learned to explain their ideas clearly.

> *We don't all have the same viewpoint and we all have to agree; that was the biggest problem. So you might have to explain different ideas and views on how the arm would work, so that was really difficult. (MESA student)*

Girls described the process of coming to agreement as learning to communicate and listen with one another in a way that was not hurtful, and that pulled the best of all ideas together.

Usually you have to give feedback to someone about why their idea wouldn't work. You can't just tell them that it is a terrible idea; you have to explain carefully, and most of the time you find that there is something really good in their idea that you can incorporate it into the group's work. (MESA student)

The girls learned to listen and not interrupt a speaker with why an idea wouldn't work.

Being able to listen to other people's ideas, and tell them that this might go wrong can be really embarrassing to do. It is hard when someone is explaining something; you have to let them finish first and then can be opinionated. (MESA student)

All students, regardless of gender, spoke about sharing responsibility—"We learned that you need to let everyone have something to do and work together equally"—and not be domineering.

People have strong ideas and dominate sometimes, but we made a better light or arm when we all worked together and shared all ideas. (MESA student)

Students learned to problem-solve as a team.

Another skill that students singled out in focus groups, but not in surveys was problem-solving. Students said that MESA taught them how to "actually problem-solve, rather than just completely start over." Specifically, students said that it was **"**easier to problem-solve working on a team," because there are "more takes on the problem" and "new ways" to think about it.

You have to collaborate with your partners to look back and go over your ideas and find where it went wrong, how it went wrong, why it went wrong, what parts broke or didn't break, and which of those pieces you could change. (MESA student)

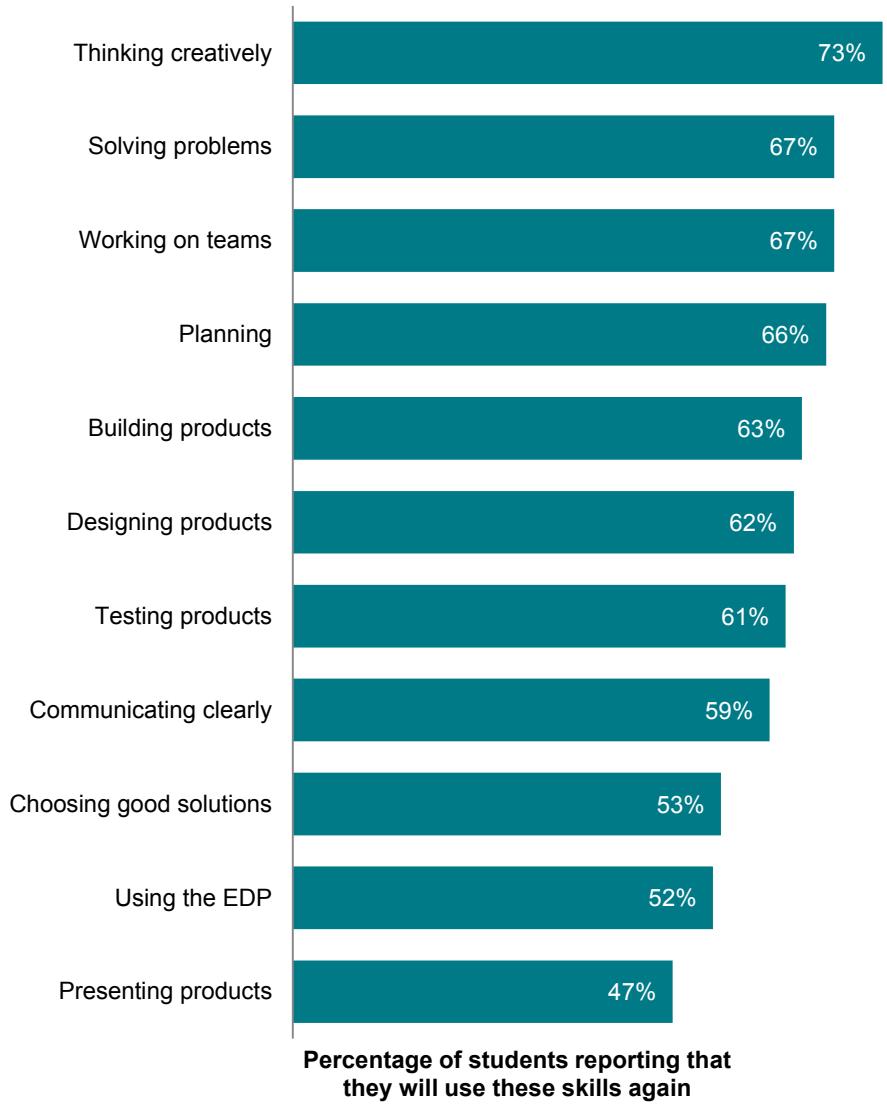
Students also learned how to brainstorm. They told us that they learned that all ideas are useful, and ones that won't work might lead to other ideas that will work.

You should say what comes to your mind, because it could be helpful or spark another idea, and you can't throw out any idea no matter how dumb it seems, because it can spark someone else to think of something else better, but if you throw it out or don't say it, that is never going to happen. (MESA student)

Students identified useful skills in surveys and focus groups.

The skills that students discussed in focus groups were similar to those they identified as most useful in surveys. Students indicated that thinking creatively, solving problems, working on teams, and planning were the skills they were most likely to use again (Figure 5).

Figure 5
In surveys, students identified useful skills.



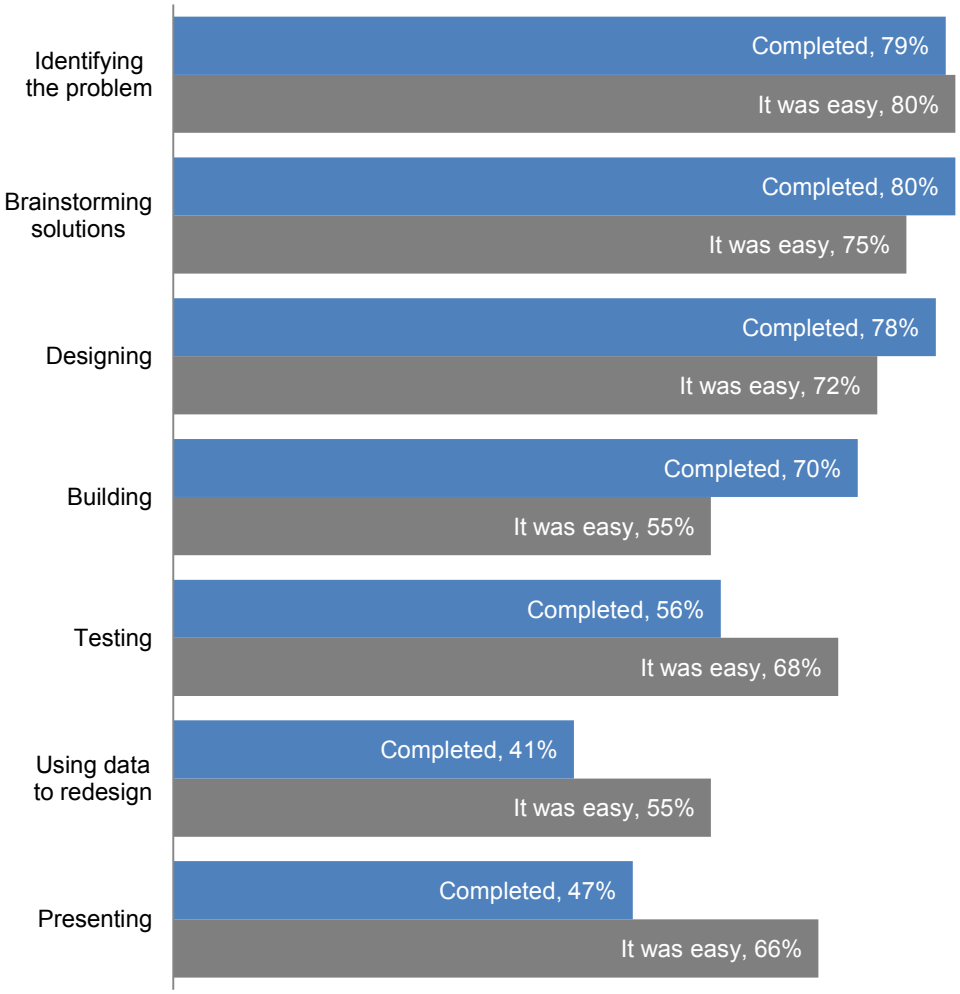
Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Did Students Complete Their Projects?

Students, working in groups, tried to design and build an invention, such as a solar lantern or water filter, by the end of the term. Nearly two-thirds (63%) of the students indicated in the survey that they completed their project and built an invention. Students who attended MESA during school hours were more likely to have reported that they completed the project.

Around three-quarters of MESA students reported that they completed the first four steps of the process—identifying the problem, brainstorming, designing and building their invention. Fewer, however, continued the project by testing, redesigning, and presenting it. The steps of the invention process that the students completed correlated to the steps that students indicated were "easy" or "very easy," except for presenting (Figure 6).

Figure 6
Steps of the process that students completed were also the ones they identified as easy.

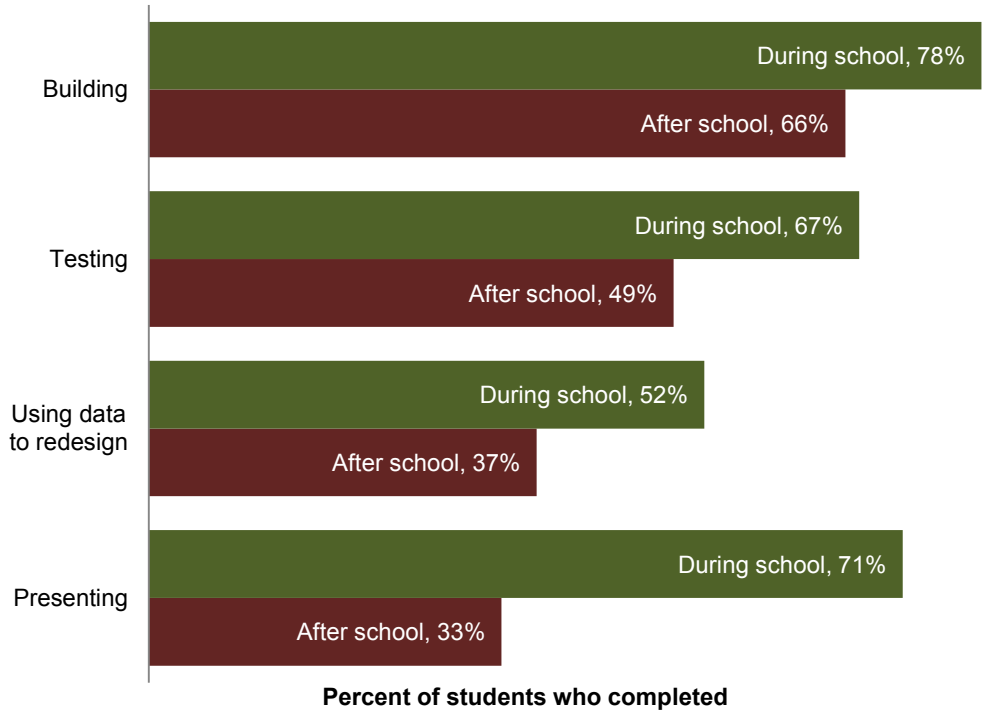


Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Students who attended MESA during-school hours completed more of the project.

Students who attended MESA during school hours were more likely to have completed the last four steps of the project (building, testing, redesigning and presenting) than those who attended MESA after school (Figure 7).

Figure 7
Students who attended MESA during school completed more of the project.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

These students, compared to those participating after school, also reported that the last four steps of the project were easier (Table 3).

Table 3
Students who attended MESA during school reported tasks were easier.

	Percent of students reporting that the task was "easy" or "very easy"	
	After school	During school
Building	45%	68%
Testing	60%	77%
Using data to redesign	51%	59%
Presenting	64%	69%

Note: All questions showed statistically significant differences between groups
Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Some students were unable to complete their project because they made mistakes or didn't plan well.

Students were asked in the survey to explain why they were unable to complete the project. Half reported that they were unable to complete the project because they ran out of time. Some wrote that they had made mistakes and lacked the time to complete the project because they went back to fix their mistakes.

> *We didn't complete it because we messed up frequently on the circuits and had to re-do them multiple times and ran out of time. (MESA student)*

Others said that it just took "longer than expected" and that much of their time was taken up "trying to figure out what to do."

A third of students indicated that they or their partner were often absent, which meant that they had much less time to complete their project.

> *We didn't complete it because my partner was almost never at MESA and ended up leaving so I never finished the lantern. (MESA student)*

Some students noted that "there were people joining and leaving our group" and they spent a lot of time catching the new members up with what they had done and what still needed to be done.

> *Sometimes we all weren't there and we sometimes forgot how to do something on the bread board and we didn't have much time. (MESA student)*

A few students noted that their project didn't work at the end of the term (14%) or that they didn't put enough effort into the project (12%). A few said that they lacked materials necessary to build invention (5%).

How Do The Curricula Influence Students?

MESA wants its students to tackle real-life problems faced by real people and to develop a sense of global citizenship, as well as build self-efficacy as inventors and designers. How do students report that the invention curricula affect their sense of global citizenship, interest in other people, and self-efficacy as inventors and designers?

Most students agreed that working on their project helped them learn about other people (86%), encouraged them to conserve energy (80%), and helped them think of new ways to be sustainable (86%). Students who attended MESA during school were more likely to show a positive change in "helping people who are poorer than you" than their peers who attended after school.

Participation in MESA also affected students' self-efficacy as inventors and designers. Nearly all students agreed that inventors help people, and about two-thirds of students could see themselves as an inventor or felt that they would make a great inventor. However, girls were less likely than boys to see themselves as an inventor.

MESA affected students' interest in learning about and helping other people.

Students were asked to evaluate their interest in helping other people, understanding how other people feel, and comparing their life to other people "before working on the project" and "now," using a four-point rubric ranging from "not interested" to "very interested."

Student self-reported interest in helping and understanding other people, and comparing their lives to others significantly increased after participation in MESA; about a third of participants reported a positive interest change after using the invention curricula. Students who attended MESA during school were more likely to show a positive change in "helping people who are poorer than you" than their peers who attended MESA after school (Table 4).

Table 4
Students reported positive change in their interest in other people and understanding of poverty.

	Percentage reporting positive change		
	During school	After school	Total
Helping people who are poorer than you*	38%	30%	33%
Understanding how other people feel	36%	29%	32%
Thinking about your life compared to other people's lives	31%	28%	29%

* Statistically significant difference between students who attend MESA during school and those who attend after school.
Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Students' ratings of their interest had a strong ceiling effect.

While a third of students reporting an increase may appear low, nearly 75 percent of students reported a high level of interest in other people *before* participating in MESA, and that after participating, more than 85 percent reported interest. Students who self-rated as "interested" or "very interested" in other people were significantly less likely to report a positive change after participating in MESA than those who selected "not interested" or a "little interested" (Table 5).

Table 5
Students who initially rated as "interested" were less likely to show improvement.

	Percent reporting positive change	
	Initial interest is "not interested" or a "little interested"	Initial interest is "interested" or "very interested"
Helping people who are poorer than you	69%	22%
Understanding how other people feel	59%	23%
Thinking about your life compared to other people's lives	58%	18%

Note: All questions showed statistically significant differences between groups
Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Girls were more interested than boys in help others and knowing about the world.

In focus groups, girls were more interested or willing to answer questions about how MESA affected their interest in helping other people and knowledge about the world. In general, boys remained largely silent when we asked about how MESA affected their interest in helping other people. Girls spoke about how MESA inspired them to help others, learn more about the world, and recognize their ability to help others. Despite these differences during the focus groups, there were no statistical differences in the survey results between boys and girls.

Girls were inspired to help, and spoke about how learning about others, especially those missing limbs, revealed to them how comfortable their own lives were, and inspired students to want to help.

> *We take so many things for granted. Last year I didn't even know about amputees in the world, I couldn't imagine it. After learning about this I just felt like I really wanted to help people who did not have what we have. (MESA student)*

One student said that her work designing a prosthetic arm was guided by how she would feel if missing a limb or what she would want in a prosthetic.

> *It made me think about if I didn't have an arm, what I would want it to do and how I would want it to look to make it comfortable and pleasing and working. (MESA student)*

Girls gained confidence and said that learning about the world and invention helped them recognize their ability to help other people.

> *MESA made me realize that I am more capable of helping than I thought I was. It made me realize for the first time that I could change things and help other people. (MESA student)*

MESA showed students that they had the ability to "make a difference in people's lives because we can engineer something that helps them." One girl told us,

> *MESA helped me recognize our ability to help other people. It helped me feel confidence in my ideas and feel confident in others' ideas so we can go out and make a difference and help others. (MESA student)*

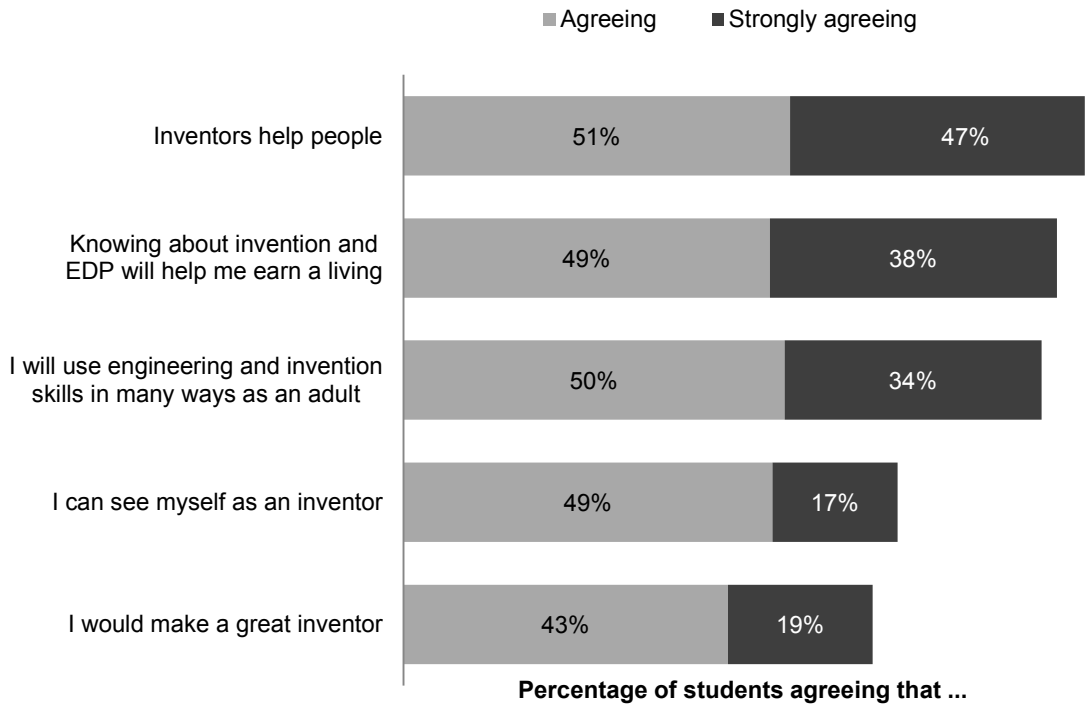
Finally, girls and boys told us that because of MESA, they felt that they knew much more about the world, and had opened their eyes and their minds to other places and other people.

> *There is so much we will never know but I know a lot more about the world than I used to. MESA got me open minded about places around the world, and how we might contribute and help. (MESA student)*

Students had positive attitudes about inventors and invention skills.

Nearly all students (Figure 8) agreed that inventors help people (98%), and most felt that they would use invention skills as an adult (85%) to help them earn a living (87%). However, fewer could see themselves as an inventor (65%) or felt that they would make a great inventor (62%).

Figure 8
Most students had positive attitudes about invention.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

In an open-ended question, more than half the students wrote that they would like to become an inventor, with many of them adding that they wanted to become an inventor to help people.

I would like to become an inventor because I see myself as a person who wants to help others and this is the best way to help others. (MESA student)

Others said that they wanted to be an inventor because they enjoyed being creative and making things.

Inventing is a very creative way to express oneself. I find joy in having to solve problems and also creating something that would be considered strange or thinking of out-of-the-box ideas, even if they do not work completely. (MESA student)

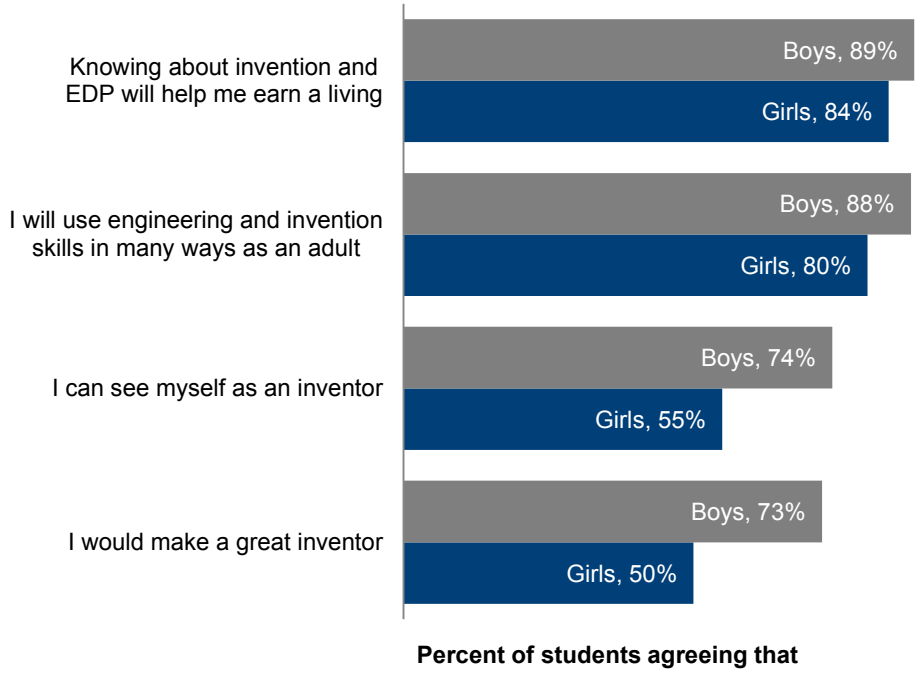
Fewer than half wrote that they did not want to become an inventor. Many of these said that while they found inventing interesting, they had other career interests.

I don't really see myself becoming an inventor, my plans lie somewhere else. I do have some ideas for possible future products, but I don't see myself in an inventing career. Not that I think I am terrible at inventing, I just don't have a passion for it. (MESA student)

Girls showed less self-efficacy as inventors than boys.

Girls were significantly less likely than boys to see themselves as an inventor or feel that they would make a great inventor. They were also less likely to agree that that they would use invention skills as an adult to help them earn a living (Figure 9).

Figure 9
Girls were less likely than boys to show self-efficacy as inventors.

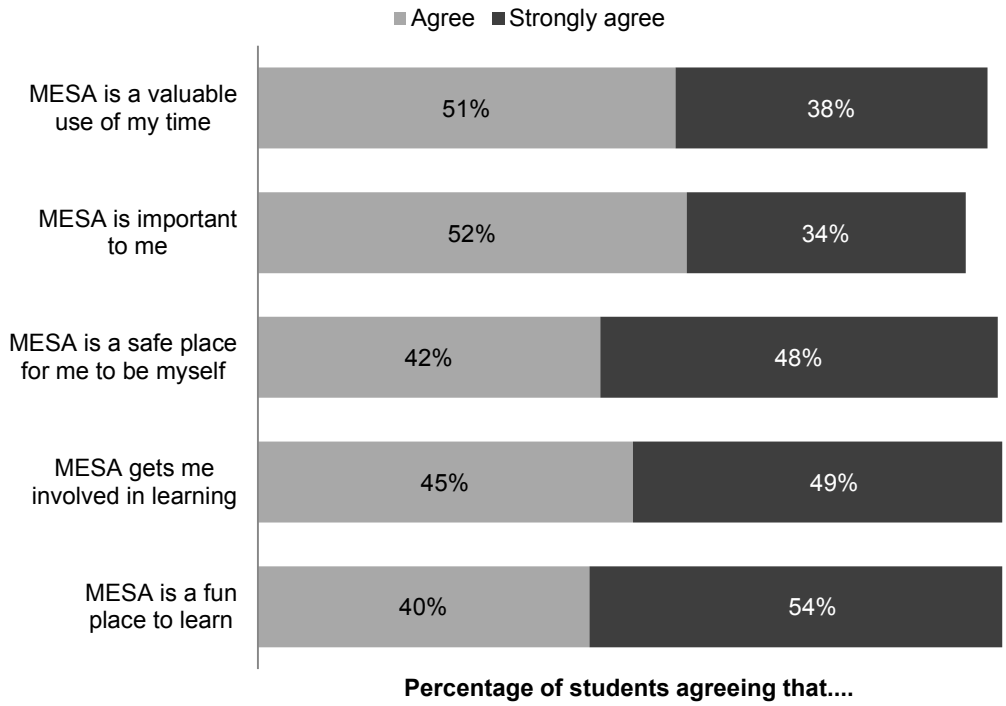


Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Students loved MESA.

Students were very positive about their experience with MESA (Figure 10). Most students agreed that MESA was a fun place to learn (94%), involved them with learning (94%), and was a safe place for them to be themselves (90%).

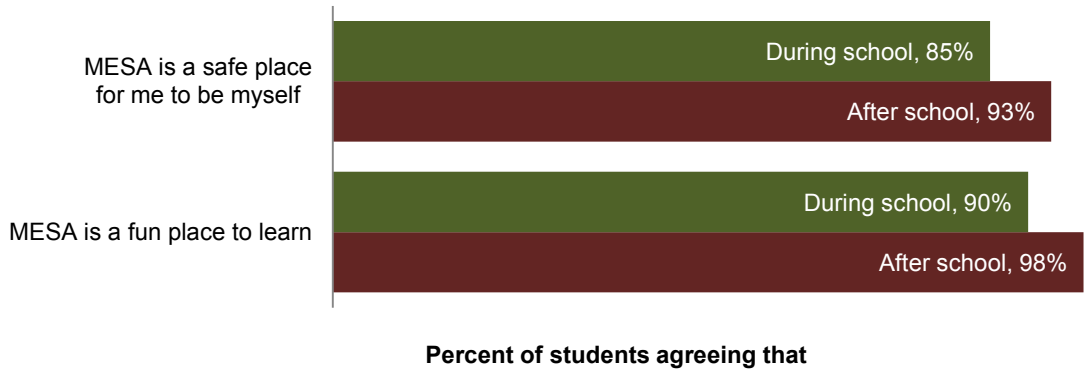
Figure 10
Students agreed that MESA was fun, safe, valuable, and important.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

While there were no differences in how boys and girls or different racial/ethnic groups responded to these questions about MESA, there were differences by level of experience and by what time of day students attended MESA. Students who attended MESA after school were more likely than students who attended MESA during school to see MESA as a fun place to learn and a safe place for them to be themselves (Figure 11), although in either setting, students were very positive about their MESA experience.

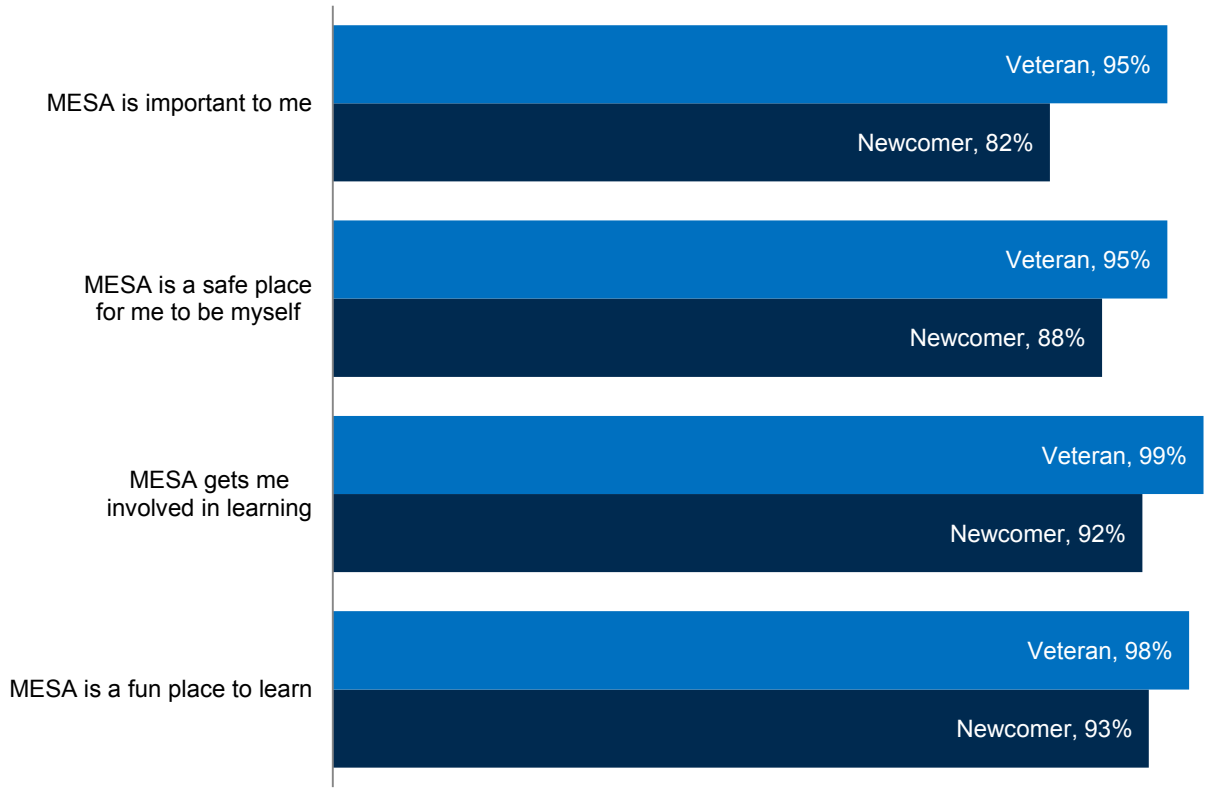
Figure 11
Students who attended after school felt MESA was safer and more fun.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Veteran MESA participants were more positive about MESA and more likely to report that MESA was a fun place to learn, got them involved in learning, was a safe place, and was important to them (Figure 12).

Figure 12
Veteran MESA students were more positive about MESA than newcomers.



Source: Combined MESA Student Surveys from 2012/13 and 2013/14

Conclusions and Future Inquiry

Overall, MESA met many of its objectives. We found that:

- Underrepresented minority students made up a significant portion of the students who participated in the projects, and that student response to the projects did not vary much by race or ethnicity.
- Most students agreed that working on their project affected their interest in learning about other people and encouraged them to conserve resources and think of new ways to promote sustainability.
- Nearly all students agreed that inventors help people, and most felt that they would use invention skills as an adult to help them earn a living; many could see themselves as an inventor.
- Students were very positive about their experience in MESA. Most agreed that MESA was fun, involved them in learning, and was a safe place to be.

However, a few important challenges stand out for MESA and the evaluation team.

- Nearly all students spoke about growth in teamwork, problem-solving, and decisions-making skills in focus groups, but these perceptions did not appear to correlate to survey results. Our hypothesis is that the survey is not capturing growth as well as it should, and needs to be retooled. This work is planned for the near future under a new Lemelson Foundation grant.
- Similarly, there was a strong ceiling effect in skill and interest growth. Students who rated their initial proficiency in skills or interest in helping and understanding others as high were significantly less likely to report a positive change after participating in MESA. It is unclear why there is a ceiling effect, but it should be explored in future focus groups with students and advisors, and should be taken into account when retooling the survey.
- Boys and girls responded to the curricula differently. Girls reported some greater skill growth but less self-efficacy as inventors than did boys. What, if anything, can be done to further understand and ameliorate these differences? Since girls appeared to respond in more detail than boys during focus groups, we suggest that this difference be explored more fully in future evaluation work using focus groups.
- Finally, it is unclear why students who attended MESA during school responded differently to the curricula than those who attended after school. It is worth exploring how different attendance times affect student perceptions. This work is planned for the near future under a new Lemelson Foundation grant.

References

Lamb, T.A., & Tschillard, R. (2005). *Evaluating learning in professional development workshops: Using the retrospective pretest*. Alexandria. VA: National Staff Development Council.

Appendix A: Student Survey Results

2012/13 data downloaded May 1, 2013 (N=202)
2013/14 data downloaded February 20, 2014 (N=216)

Thank you for taking this survey!

We will ask you questions about your experience with MESA and the Invention Curricula. This will provide MESA with information to improve its work and reach out to other students.

Your answers are completely confidential. Your comments and ratings will never be used with your name or your school's name, will never be given to your teacher, and will never be used to judge or evaluate you or your teacher.

If you have questions about this survey, please contact Dr. Jason Greenberg Motamedi, at 503.275.9493. Thank you for your help!

What grade are you in? (N=200, 216)

Grade	2013	2014	Total
5	0%	1%	0%
6	8%	26%	17%
7	47%	33%	40%
8	31%	18%	24%
9	4%	6%	5%
10	9%	6%	7%
11	2%	6%	4%
12	1%	4%	2%

I am a ... (N= 200, 215)

Gender	2013	2014	Total
Girl	54%	40%	47%
Boy	47%	60%	53%

What is your ethnicity? (N= 197, 210)

Race/Ethnicity	2013	2014	Total
Multiracial or other	9%	20%	14%
Alaskan Native/Native American	1%	1%	1%
Black/African American	3%	9%	6%
White/Caucasian	30%	34%	32%
Asian/Pacific Islander	14%	17%	15%
Hispanic/Latino	43%	20%	31%

How many years have you been in MESA, including this year?

2013 Mean: 1.4 years, Range: 1–5 years (N=200)
2014 Mean: 1.4 years, Range: 1–7 years (N=216)
Total Mean: 1.4 years, Range: 1–7 years (N=417)

When do you attend MESA? (N= 199, 216)

	2013	2014	Total
During school	53%	31%	41%
After school	47%	69%	59%

Has someone in your close family gone to college? (N= 198, 216)

	2013	2014	Total
No	29%	24%	26%
Yes, one person	20%	24%	22%
Yes, more than one person	51%	53%	52%

These questions ask about the skills you need to be an inventor. Please rate your skills BEFORE working on the project and how your skills are NOW.

If you are **great** at these skills**,** you feel that this is really easy and you can do this with your eyes closed
If you are **good** you feel it is mostly easy to do, but sometimes a little tricky
If you **could be better**, it is pretty hard and takes work
If you are **bad news**, this is really hard and takes a lot of work

		Percent "good" or "great"		
		2013	2014	Total
Planning	Before (N = 202, 212)	73%	63%	68%
	Now (N = 202, 209)	92%	90%	91%
Using the engineering design process	Before (N = 202, 212)	57%	50%	53%
	Now (N = 202, 209)	83%	88%	86%
Choosing good solutions to design problem	Before (N = 198, 210)	75%	64%	69%
	Now (N = 198, 208)	91%	92%	92%
Working on teams	Before (N = 201, 210)	86%	78%	82%
	Now (N = 201, 209)	93%	91%	92%
Designing products	Before (N = 201, 213)	66%	69%	67%
	Now (N = 201, 211)	89%	89%	89%
Building products	Before (N = 201, 208)	73%	63%	68%
	Now (N = 201, 206)	89%	90%	89%
Testing products	Before (N = 201, 211)	80%	73%	77%
	Now (N = 200, 208)	92%	94%	93%
Presenting products	Before (N = 200, 212)	55%	49%	52%
	Now (N = 201, 210)	77%	76%	77%
Solving problems	Before (N = 200, 211)	78%	72%	75%
	Now (N = 201, 208)	92%	91%	91%
Thinking creatively	Before (N = 201, 209)	84%	79%	82%
	Now (N = 202, 207)	91%	94%	93%
Communicating clearly	Before (N = 202, 211)	75%	66%	70%
	Now (N = 202, 210)	87%	86%	86%

Which of these skills will you use AFTER the project? (N= 202, 216)

	2013	2014	Total
Planning	63%	69%	66%
Using the engineering design process	46%	58%	52%
Choosing good solutions	52%	53%	53%
Working on teams	61%	74%	67%
Designing products	58%	67%	62%
Building products	59%	66%	63%
Testing products	59%	63%	61%
Presenting products	47%	48%	47%
Solving problems	68%	67%	67%
Thinking creatively	70%	76%	73%
Communicating clearly	57%	61%	59%

How interested were you in these things BEFORE working on the project and how interested are you NOW?

If you are **very interested** you think about this all the time
If you are **interested** you think about this often
If you are **a little interested** you think about this sometimes
If you are **not interested** you almost never think about this

		Percent "interested" or "very interested"		
		2013	2014	Total
Helping people who are poorer than you BEFORE and AFTER working on the project?	Before (N = 202, 208)	79%	71%	75%
	Now (N = 202, 207)	92%	90%	91%
Understanding how other people feel BEFORE and AFTER working on this project	Before (N = 202, 207)	74%	74%	74%
	Now (N = 202, 207)	86%	86%	86%
Thinking about your life compared to other people's lives BEFORE and AFTER working on this project	Before (N = 202, 208)	73%	69%	71%
	Now (N = 202, 207)	86%	85%	85%

The next three sets of questions ask if you agree or disagree.

If you **strongly agree** you feel that the statement is 100 percent right.
If you **agree** you feel it is mostly right.
If you **disagree,** it is mostly wrong.
If you **strongly disagree**, it is all wrong.

	Percent "agree" or "strongly agree"		
	2013	2014	Total
Inventors help people. (N = 201, 211)	98%	98%	98%
I can see myself as an inventor. (N = 200, 211)	64%	67%	65%
Knowing about invention and the engineering design process will help me earn a living. (N = 200, 210)	85%	89%	87%
I will use engineering and invention skills in many ways as an adult. (N = 199, 209)	84%	85%	85%
I would make a great inventor. (N = 198, 209)	58%	66%	62%

	Percent "agree" or "strongly agree"		
	2013	2014	Total
MESA is a fun place to learn. (N = 200, 208)	93%	96%	94%
MESA gets me involved in learning. (N = 199, 208)	93%	96%	94%
MESA is a safe place for me to be myself. (N = 200, 207)	89%	91%	90%
MESA is important to me. (N = 200, 208)	85%	87%	86%
MESA is a valuable use of my time. (N = 200, 207)	85%	92%	88%

Working on this project has

	Percent "agree" or "strongly agree"		
	2013	2014	Total
helped me learn about other people. (N = 202, 206)	82%	89%	86%
encouraged me to conserve (N = 202, 206)	80%	81%	80%
helped me think of new ways to be sustainable. (N = 202, 206)	87%	85%	86%

Did you complete your project?

2013 (64%) Yes, we completed our project (N = 194)
2014 (62%) Yes, we completed our project (N = 199)
Total (63%) Yes, we completed our project (N = 393)

How far did your team get designing your project? Please tell us how hard the tasks were, and which you finished.

	Percent reporting tasks were "easy" or "very easy"		
	2013	2014	Total
Identifying the problem (n= 165, 166)	82%	78%	80%
Brainstorming different solutions (n= 157, 155)	78%	73%	75%
Designing the product (n = 155, 143)	77%	68%	72%
Building the product (n = 117, 104)	58%	52%	55%
Testing the product (n = 131, 120)	65%	71%	68%
Using data to redesign the product (n = 98, 100)	49%	62%	55%
Presenting the product (n = 121, 156)	60%	72%	66%
Working on teams (n = 166, 131)	82%	73%	78%

How far did your team get designing your project? (N=202, 216)

	Percent reporting they complete these tasks		
	2013	2014	Total
Identifying the problem	85%	75%	79%
Brainstorming different solutions	86%	74%	80%
Designing	83%	74%	78%
Building	77%	65%	70%
Testing	63%	50%	56%
Using data to redesign	37%	43%	41%
Presenting	55%	41%	47%
Working with others on teams	69%	55%	62%

Appendix B: Focus Group Protocol

1. My first question is pretty simple: What have you learned in MESA? Give me a list of the top things you have learned.
2. What have you learned about working in a group or with others on complex problems?
    a. What has been hard about working with others?
    b. What have you gained from working with others?
3. What have you learned about thinking creatively and problem-solving?
    a. What sort of lessons have you learned which you could apply to other areas?
4. How has MESA affected your interest in engineering and computer science?
    a. Does working on these projects increase your interest in being an inventor?
5. Which MESA curricula have you used? Solar lighting, prosthetics, water transportation, or water filtration?
6. The MESA curricula had you design something for a particular need (like getting clean water, light to do homework, or carrying water) that you, living in Portland, probably don't have. How has thinking about these needs affected you?
    a. How has it affected your interest and knowledge of the world?
    b. How has it affected your interest in helping other people?
7. What differences, if any, have you seen between how girls and boys work in MESA?
8. Do you have any other comments about MESA?