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Student Science Self Perceptions: Summary of Survey Responses from the Laying the Foundation Program

Julia Phelan
University of California, Los Angeles

Marsha Ing
University of California, Riverside

Karen Nylund-Gibson
University of California, Santa Barbara

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ABSTRACT

Long-term persistence in STEM fields depends on students acquiring a solid foundation in math and science. Math and science achievement alone, however, does not fully account for the low persistence often seen in STEM fields. Research suggests that other factors such as students' self-perceptions can influence persistence in STEM fields. This study explored science self-perceptions of eighth graders enrolled in physical science. Teachers of these students participated in the Laying the Foundation (LTF) professional development program. Findings are consistent with other research which suggests that there is a relationship between student self-perceptions and interest in science



INTRODUCTION

The underlying goals of this project were to continue the collaboration between the Alabama State Department of Education (ALSDE), the National Math + Science Initiative (NMSI) and A+ College Ready to assess the impact of Laying The Foundation-infused courses on student achievement as measured by ACT's ASPIRE assessments. The study focused on student outcomes in mathematics and ELA in grades 8 and 10, and science in grade 8 in the 51 schools.

In 2015-2016 a new cohort of teachers (Cohort VIII) joined 118 Alabama high schools in the ALSDE/A+ College Ready Program (using the Laying the Foundation lessons). The LTF initiative includes comprehensive teacher training and student support to boost enrollment and success in Advanced Placement (AP[®]) courses in mathematics, science and English, and the rigorous courses that lead up to AP. The overarching study (of which one component will be described here) was designed to explore student outcomes in the Cohort VIII schools (including feeder schools) of the LTF initiative in mathematics, English and science.

Schools invited to become ALSDE/A+ College Ready Cohort VIII Schools agreed to embrace an ambitious plan to train teachers, implement rigorous CCRS-aligned courses, establish vertical team meetings, change policies and procedures and share data to better prepare students and teachers for success in a college readiness and the AP program.

In order to gather data on implementation of the LTF curriculum we developed a set of surveys, online teacher logs as well as observation protocols. Included in these measures were a student survey designed to measure students' self-perceptions and interests. Specific versions of the surveys were created to focus on English, science and math and in this report we present descriptive analyses of the student self-perception surveys focused on perceptions about science.

The design of the self-perception survey was grounded in the expectancy-value theory of achievement motivation. This theory incorporates people's beliefs about how well they will do on the task and the extent to which they value the task (Atkinson, 1957; Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983; Wigfield, 1994; Wigfield & Eccles, 1992, 2000). The theory includes three interrelated constructs: ability belief, expectancy, and value. Ability belief and expectancy are both related to an individual's perceptions of how they do on a task or in a particular subject area currently (ability) or in future (expectancy). Value includes "attainment value or importance, intrinsic value, utility value or usefulness of the task and cost" (Wigfield & Eccles, 2000, p. 72). Variation in children's ability-expectancy beliefs is domain



specific (Eccles et al., 1983; Wigfield, Eccles, Mac Iver, Reuman, & Midgley, 1991). For example, positive beliefs about ability beliefs and values in science are different from ability beliefs and values in art.

In studies specific to math and science, research indicates a positive association between perceived values/ability and achievement in mathematics and science (Wigfield et al., 1991), as well as participation in out-of-school mathematics and science activities (Simpkins, Davis-Kean, & Eccles, 2006), and intention to enroll in mathematics and science courses (Atwater, Wiggins, & Gardner, 1995). In other words, those students who see themselves as being good at math, or expect to do well and continue studying math, tend to have higher achievement and participation in math-related activities than those who do not see themselves so.

This particular theory of achievement-motivation informs our work through its emphasis on student beliefs about whether they can and want to learn science and whether they see themselves as having a job in the future which utilizes science-specific learning. This framework is particularly applicable to middle school students' perceptions as this is a critical time for making decisions such as which high school science courses to enroll in and in which extracurricular activities they participate (Wigfield, Eccles, Yoon, Harold, Argreton, Freedman-Doan, & Blumenfeld, 1997).

Self-perceptions about science ability and value will also likely impact students' persistence at learning science and their choices related to career interests. Identifying and better understanding these perceptions may in turn help us successfully invite more students to learn science and consider science-related careers.

METHODOLOGY

Packages with 40 paper copies of the student surveys were mailed to participating science teachers in the fall (2015) and spring (2016). Teachers administered and returned the surveys once complete. Of the 19 teachers with signed letters of agreement, 8 teacher returned their student surveys in the fall (42%, n = 268 student surveys) and 6 teachers returned student surveys in the spring (32%, n = 241 student surveys). The number of student surveys returned per teacher ranged from 17 to 66. On average, approximately 36 surveys per teacher were returned. Eight teachers requested feedback on their fall student surveys and were sent a two-page summary (Appendix A) in February 2016.

The student surveys included questions about students' science self-perceptions (such as how much they like doing science), opportunities to learn science (such as how frequently they



design their own experiments) and aspirations in science (such as whether they want to take more science courses in high school). What we report in this technical report does not include all of the items that were included in the survey or in the two-page summary given to teachers. Instead the data included in this technical report are based on the items that were selected after initial analyses. We excluded, for example, items that did not show much variation in responses or did not correlate highly with the other variables.

Self-Perceptions: The first 8 items focused on students' science self-perceptions (Table 1). Survey items were based on the expectancy-value achievement motivation theory framework (described above) which suggests that student performance and persistence are influenced by students' beliefs in their abilities and the extent to which they value the activities in which they (Atwater et al., 1995; Simpkins et al., 2006; Wigfield et al., 1991). The original items included four response options (strongly disagree, disagree, agree, strongly agree). However, due to skewed distributions, with most students selecting disagree or agree across most items (rather than the more extreme response options), we collapsed the response options from four to two. The two response options are agree (1) which included agree and strongly agree and disagree (0) which included disagree and strongly disagree. A composite score to indicate science self-perceptions was created by summing scores on these eight dichotomous items (maximum score is 8; fall: $M = 6.81$, $SD = 1.63$; spring: $M = 6.40$, $SD = 2.04$).

Opportunity to Learn: In addition to the self-perception items, the survey included items focused on students' perceived opportunities to learn (OTL) science. The OTL science items were from previous research conducted by Pamela Aschbacher, a K-12 science education expert at Caltech (Aschbacher, Ing, & Tsai, 2014, 2015; Aschbacher, Li, & Roth, 2010; Table 2). Similar to the rationale for dichotomizing the self-perception items, these OTL items were also collapsed to dichotomous response options (disagree, agree). A composite score which summed the dichotomous items was used to represent student-perceived opportunities to learn science (maximum score is 10; fall: $M = 5.00$, $SD = 2.94$; spring: $M = 5.54$, $SD = 3.23$).

Student Interest in Science: The three items related to students' interest in science were:

- I would like to work in a career involving science
- I would like to take more science courses in high school
- I would like to study science after high school

Similar to the rationale for dichotomizing the self-perception and OTL items, these items were collapsed to dichotomous response options (disagree, agree). A composite score to indicate interest in science was created by adding scores for these three items.



Linear regression analyses were conducted to explore the relationship between perceived opportunities to learn science, science self-perceptions and interest in science.

A non-random sample of 16 students was interviewed in June about their science self-perceptions. Interview items were pilot tested with middle school students in Santa Barbara. Revisions were made based on feedback from interviewers about what questions provided information about student interpretation of the items. In addition, two members of the research team listened to audio recordings of all the interviews and revised the protocol before gathering data from students in Alabama. The interview protocol was structured and interviewers did not probe for additional responses. The purpose of the interview was to gather evidence for student interpretation of the survey items.

RESULTS

Student self-perceptions were similar in the fall and spring (Table 1). Based on the composite score for student self-perceptions, there were no gender differences in the fall, $t(266) = 1.13$, $p = .26$, or spring, $t(239) = -0.10$, $p = .92$. There were also no differences by ethnicity for either the fall, $t(266) = 1.76$, $p = .08$, or Spring, $t(239) = -1.16$, $p = .25$.

Table 1. Descriptive statistics for science self-perception items.

	Fall		Spring	
	M	SD	M	SD
I am good at science	0.87	0.33	0.83	0.38
I learn new ideas in science easily	0.75	0.43	0.70	0.46
I expect to do well in science this year	0.96	0.19	0.90	0.29
I could be good at science	0.95	0.22	0.91	0.28
It is useful for me to know some science	0.90	0.31	0.88	0.33
Being good at science is important to me	0.76	0.43	0.74	0.44
I think science is interesting	0.84	0.36	0.74	0.44
I like doing science	0.78	0.42	0.70	0.46



Student perceived opportunities to learn were similar in the fall and spring (Table 2). There were no gender or ethnicity-based differences in perceived opportunities to learn.

Table 2. Descriptive statistics for science OTL items.

	Fall		Spring	
	M	SD	M	SD
I am given the opportunity to explain my ideas	0.72	0.45	0.72	0.45
I spend time in the laboratory doing experiments	0.41	0.49	0.48	0.50
I design how a science question could be investigated in the laboratory	0.44	0.50	0.49	0.50
I apply a science concept to everyday problems	0.37	0.48	0.42	0.50
I share my opinion about science topics with other students	0.56	0.50	0.55	0.50
I draw conclusions from an experiment I conducted	0.61	0.49	0.64	0.48
I design my own experiments	0.22	0.41	0.33	0.47
I use charts, graphs or tables to record my data	0.66	0.47	0.70	0.46
I talk to other students about the results of an experiment	0.59	0.49	0.70	0.46
I write about the science ideas we are studying	0.44	0.50	0.51	0.50

Approximately half of the students expressed interest in a career that required some science and wanting to take more science classes after high school (Figure 1). The percentages were similar for the fall and spring survey responses. Students expressed interest in taking more science in high school. Almost 70% of students expressed interest in taking more science in high school. However, students who were interviewed (although not a representative sample) were aware that taking more science in high school was required. Thus, their interest in taking more science class might be due to their interest in fulfilling the high school graduation requirements.



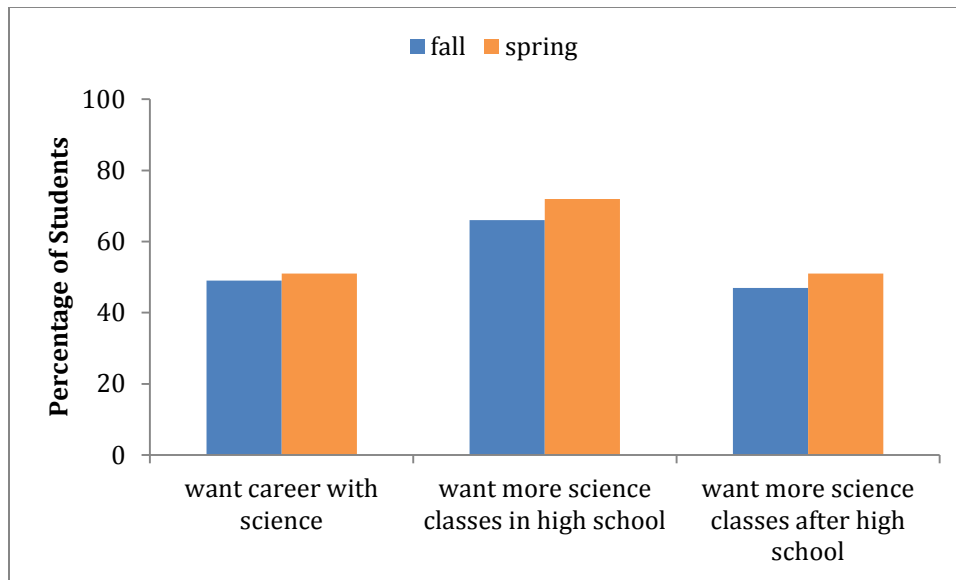


Figure 1. Self-reported student interest in science.

There were positive and significant correlations between student self-perceptions and interest in science for the fall ($r = .48$) and spring ($r = .52$) survey responses.

Regression analyses suggest that self-perceptions and opportunities to learn science relate to student interest in science (Table 3). Although these analyses do not include classroom or teacher predictors such as teacher implementation of the professional development program, these models cluster standard errors to account for the nested structure of the data.

Table 3. Summary of regression analysis predicting student interest in science based on spring data

	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Perceived opportunities	0.13	0.02	0.35**				0.05	0.01	0.12*
Self-perceptions				0.31	0.04	0.51**	0.28	0.05	0.46**
R^2	0.12			0.27			0.28		
	$F(3, 5) = 32.23^{**}$			$F(3, 5) = 38.95^{**}$			$F(4, 5) = 178.50^{**}$		

* $p < .01$. ** $p < .001$.

Additional models were run to look at the relationship for teachers with student survey data at both time points. The relationships were similar between self-perceptions and interest in science for the reduced sample of teachers. In addition, controlling for average classroom level of interest seen in the fall surveys, there was still a significant relationship in the spring between self-perceptions and interest in science.



DISCUSSION & CONCLUSIONS

Findings suggest a positive relationship between students' science self-perceptions and interest in science. Students' perceptions of themselves in science may influence whether they want to learn more science in the future and ultimately pursue careers in science. These findings also suggest that although perceived opportunities to learn science are important for students wanting to learn more science, the relationship between these variables is influenced by student self-perceptions. In other words, students might report positive experiences in learning science but if they do not perceive science to be useful and valuable to their lives, they are not likely to show interest in science.

There are several limitations of these findings. First, we were not able to link student responses in the fall and spring. Thus, while the fall and spring samples come from the same population of Alabama teachers who participate in the professional development program, the students of those teachers might change from the fall to the spring. This limits our ability to discuss growth or change between the fall and spring. To attempt to address this limitation, we ran analyses for teachers with student responses in both the fall and spring (and found similar relationships between the variables) but we do not have student-level information to compare how the same students responded in the fall and spring.

Second, we were also not able to link student responses to administrative and student outcome data. Without this information, we could not validate student reports of gender, ethnicity, or student science achievement. We were not able to confirm whether students who reported a particular ethnicity are also categorized similarly in the district administrative records. We were also not able to confirm whether students who reported that they were good at science were actually the same students who received high grades in science or who had high scores on standardized science achievement measures. Without being able to validate the data, the self-report nature of the study data is limiting.

Finally, although we statistically adjusted for differences between classrooms, these analyses do not include classroom or teacher-level characteristics that might help explain the variation between classrooms. This is due in part to the low completion rates compared to other classroom measures (such as teacher surveys, logs, observations). This limits our ability to attribute differences in student interests to specific teacher characteristics (such as how well the teacher implemented the professional development program).



Despite these limitations, self-perceptions should be considered when trying to understand the context in which the professional development is implemented. For example, teachers who are teaching science in a classroom where a greater proportion of students report high self-perceptions in science might have a different classroom environment than teachers who are teaching science in a classroom where a larger proportion of students report low self-perceptions. Self-perceptions might have indirect relationships with important student outcomes such as achievement and persistence in STEM careers. Since teachers have influence on both learning activities and students' sense of self as a science learner, these results underscore the importance of preparing teachers to foster student desire to learn more science in the future.



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February 10, 2016

Dear Amanda,

Thank you for your participation in the study conducted by the Alabama State Department of Education (ALSDE), A+ College Ready and the National Math + Science Initiative (NMSI) to assess the impact of the Laying the Foundation lessons in your classroom.

As part of the study, you administered surveys to students in your physical science courses in the fall. The surveys included questions about your students’ science self-perceptions (such as how much they like doing science), their opportunities to learn science (such as how frequently they design their own experiments) and their aspirations in science (such as whether they want to take more science courses in high school). We are in the process of analyzing data collected in the fall but wanted to provide you with brief, initial results for your students.

We averaged scores from your students’ responses across items for each of the three areas (science self-perceptions, opportunities to learn science, science aspirations). For the ten items related to science self-perceptions, students provided responses that indicated whether they strongly agree (4), agree (3), disagree (2) or strongly disagree (1) to items such as, “I learn new ideas in science easily” or “I like doing science.” The maximum possible score is 4 for each question.

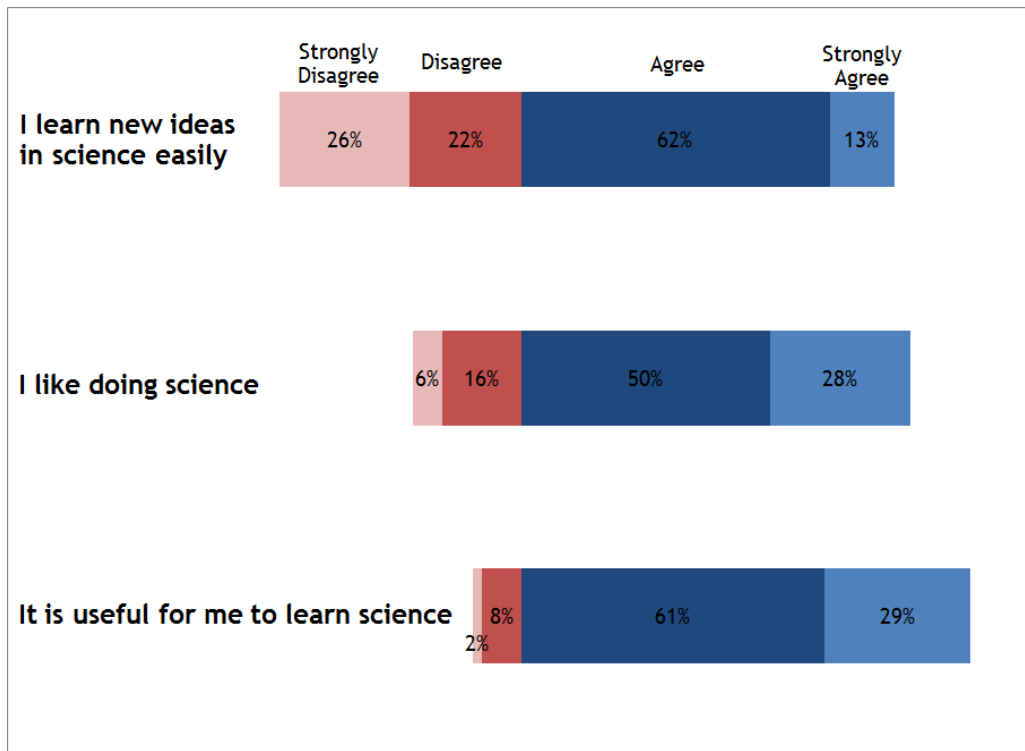
Students with higher scores indicated more positive science self-perceptions, and those with lower scores indicated less positive science self-perceptions. We calculated an average score based on student responses to all ten items. We created similar average scores for items related to the other two areas (10 items related to opportunities to learn science and eight items related to science aspirations). Below is a summary table describing your average student survey responses and the overall average for all students in Alabama who completed the survey.

	<i>Your Students</i> (<i>n = 17</i>)		<i>Alabama Students</i> (<i>n = 262</i>)	
	<i>Mean</i>	<i>Standard Deviation¹</i>	<i>Mean</i>	<i>Standard Deviation</i>
<i>Science Self-Perceptions</i>	3.21	0.34	3.06	0.44
<i>Opportunities to Learn Science</i>	2.62	0.59	2.51	0.60
<i>Science Aspirations</i>	2.76	0.80	2.38	0.84

¹The standard deviation is a measure of the spread of the student responses. A higher standard deviation indicates greater range in student responses. A lower standard deviation indicates less range in student responses.

Science Self-Perceptions

The figure below describes how 262 Alabama students responded to three of the ten science self-perception items.



Relationship to Other Areas

There is a relationship between science self-perception scores and scores on the other two areas (opportunities to learn science and science aspirations). Students with more positive science self-perceptions were more likely to express interest in taking more science courses in high school and work in a career involving science. Students with less positive science self-perceptions were less likely to want to take more science courses in high school or to work in a career involving science. In addition, students with more opportunities to learn science were also more likely to express positive science self-perceptions.

The survey responses were anonymous (we could not identify how individual students responded) and will not be used to evaluate your teaching. Instead, consider this information about your students' science perceptions that could be used as another indicator to better understand your students. If you have any questions, please contact Marsha Ing (marsha.ing@ucr.edu) or Julia Phelan (julia.phelan@ucla.edu). Thank you for helping with this effort. We appreciate your assistance.

Sincerely,

Julia Phelan, Ph.D.