Science Instructional Time and the Relationship with Science Achievement for Students with Significant Cognitive Disabilities

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This research represents the contributions to a body of work in the service of supporting a meaningful assessment system designed to serve students with the most significant cognitive disabilities. All members of the ATLAS staff have contributed to this undertaking. We acknowledge them all for their contributions. The authors wish to acknowledge Amy Clark and Brianna Beitling for their work on the annual teacher survey used in this study as well as Meagan Karvonen for her review and feedback on a draft of this paper.

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Abstract

A history of poor opportunity to learn (OTL) science for students with significant cognitive disabilities (SCD) has impacted their science achievement. Previous studies have found that achievement is correlated with OTL for students without disabilities (e.g., Lavy, 2015) and for students with disabilities (e.g., Karvonen & Huynh, 2007) and that science achievement is correlated with science OTL for students without disabilities (e.g., Blank, 2013), but little is known about correlations between science achievement and science OTL for students with SCD. We describe science instructional time (IT), changes in science IT from 2017 to 2018, and the relationship between IT and achievement for students with SCD. Teachers (n = 6,619 in 2017 and n = 11,542 in 2018) from states participating in DLM science assessments reported IT by science domain or core ideas within domains, and by science and engineering practice (SEP) for each student. The most commonly reported amount of time spent instructing students was 1 to 10 hours. Frequency distributions of IT by domain and SEP were generally consistent from 2017 to 2018. However, the frequencies of teachers reporting zero hours of IT were notably higher for three SEPs than other SEPs. As expected, the correlation coefficients between IT and achievement were positive and low. The implications of these findings are discussed.

Introduction

Historically, students with SCD have had low OTL in science content linked to the grade-level standards because instruction has focused on functional skills (Courtade, Spooner, & Browder, 2007; Karvonen et al., 2011; Spooner et al., 2014). Since 2001, federal regulations have mandated these students be taught science content that is linked to grade-level standards (Kingston et al., 2016) and the publication of the Next Generation Science Standards in 2013 expanded science content to include not only disciplinary core ideas, but also science and engineering practices, and cross cutting concepts. In response, a consortium of states adopted new alternate content standards, called Essential Elements (EEs), that are reduced in breadth, depth, and complexity from the NGSS standards (DLM, 2015). This consortium has grown to 14 states including over 33,000 students in 2018.

The first operational science assessments were administered in 2016 (DLM, 2017). Observed low performance on the assessments was not surprising and could be caused by many factors, such as the magnitude of the change in expectations from previous science content standards, students' prior low access to science instruction, special educators' lack of science content knowledge and lack of preparation to teach science, as well as a lack of curricular supports for teaching science. Thirty-nine states have adopted the NGSS or similar standards (Achieve, June 2018), have (or will) administer alternate assessments aligned to these standards, and have to contend with the same challenges that the DLM Consortium has faced. Appropriate interpretation of test scores requires access to OTL data that can help stakeholders make inferences from student achievement data (NRC, 2002).

After educators have access to appropriate science professional development and aligned curricular supports, students with SCD should have increased science OTL (Quenemoen et al., 2001) and achievement. Research in other content areas has shown a positive relationship between students' OTL and their performance on alternate assessments (Karvonen & Huynh, 2007; Roach & Elliott, 2006). Therefore, it is important to measure OTL and track OTL over time in relationship to science achievement.

Objective

Research has shown that science achievement among students without disabilities depends on science OTL, as measured by hours of instructional time (IT; e.g., Blank, 2013; Lavy, 2015). The purpose of this study is to describe science IT for students with SCD and determine the relationship between IT and achievement in science.

Research questions guiding this study are:

1. How much science IT is delivered to students with SCD?
    a. How much science IT is delivered to students with SCD by domain?
    b. How much science IT is delivered to students by SEP?
    c. Has science IT changed from 2017 to 2018?
2. Is science IT related to science achievement for students with SCD?

Theoretical Framework

In general, access to standards-linked instruction has been an issue of concern for students with SCD (Karvonen et al., 2011) and recently instructional areas of concern for these students have been expanded to include science instruction (e.g., Rogers, Thurlow, & Lazarus, 2015). Despite an emphasis on *science for all* in science education policy (e.g., NRC, 2012), enacted science curricula for these students often differs greatly from that of their general education peers, consisting primarily of functional skills rather than academic content (Courtade et al., 2007; Spooner et al., 2014). In other words, science instruction experienced by students with SCD has typically not included the science concepts that their peers were provided or has provided content that was appropriate for much younger students (Courtade et al., 2007). This history of poor access has implications for science achievement and demands measurement of these students' opportunities to learn science.

Opportunity to learn (OTL) is a complex construct that has been measured in a variety of ways (Floden, 2002). Critical aspects of OTL include: instructional time (IT), quality of instruction, alignment of instruction and assessment, and student engagement (Floden, 2002). In other words, IT does not completely describe OTL, however, IT does provide useful information for stakeholders and policy makers. Positive relationships have been identified between IT and student achievement for general education students (Blank, 2013; Dagli, 2018; Lavy, 2015; NRC, 2002). For example, Blank (2013) found a positive relationship between the average number of hours of science instruction per week to 4^{th} graders' science achievement. However, additional IT does not always make up for differences in achievement due to other factors, such as differences in levels of initial knowledge, socio-economic status, initial IT, or other student demographic variables (Blank, 2013; Lavy, 2015). Despite shortcomings, IT is often the sole indicator of OTL due to large respondent burden in gathering the data necessary to completely describe OTL (Floden, 2002). Based on prior findings for students without disabilities, we expect a positive, but small, relationship between IT and achievement in science for students with SCD.

The Dynamic Learning Maps Alternate Assessment System (DLM) in science is based on alternate content standards called Essential Elements (EEs) that each are linked to a corresponding NGSS performance expectation. However, for students’ scores on these assessments to represent what they know and can do in science, instruction and assessment must align to the EEs. Each EE aligns with one science domain (life science, Earth and space science, or physical science), one disciplinary core idea (DCIs; i.e., science topic), and one science and engineering practice (SEP). In each assessed grade span (elementary, middle, and high school), students are tested on a range of content that includes the three science domains and a selection of DCIs and SEPs. Testlets (sets of 3 to 5 related items) were developed using an established process that included multiple checks for alignment with DCIs and SEPs (DLM, 2017). Evidence supporting the alignment among the alternate content standards and the assessment has been previously reported (DLM, 2017; Andersen, Nash, & Bechard, 2018). In this paper, we provide evidence related to instruction and achievement by describing science IT for students with SCD, how IT has changed across two academic years, and the relationship between IT and student achievement.

Methods

Data Sources

Teacher survey. An annual teacher survey was used to collect information about science IT for each student. Each spring, teachers report IT within each science domain and SEP for each of their students. Student science achievement is measured by an alternate assessment aligned to the EEs that is also administered each spring. Both measures are described below in more detail. For the purpose of this research, only students who participated in the assessment in 2017 or 2018 and whose teacher completed the science portion of the teacher survey about the student in the corresponding year, were included in the analyses.

The teacher survey is administered each year in the spring within the same online system that student assessments are administered. The survey is assigned at the student level and teachers respond to the survey about the student that it is assigned to. Teachers typically respond to the survey for between one and three students. The teacher survey serves many purposes for the DLM assessment system including, but not limited to, collecting information regarding the amount of time teachers spend instructing in subject areas. The survey is comprised of several blocks of questions; two of which are fixed, meaning all teachers receive them, and several blocks that are spiraled, meaning they are randomly assigned based on eligibility criteria. One spiraled block consisted of questions about science.

Within the spiraled science block of questions, teachers were asked to indicate the number of hours they spent instructing the student on each science domain (2017) or on each core idea within the domains (2018) as well on each SEP during the academic year using a 5-point ordinal scale: *none, 1-10 hours, 11-20 hours, 21-30 hours, or more than 30 hours*. The domains and core ideas on the survey represent the areas that are assessed on the DLM science assessments. IT is operationally defined by the range of hours reported on this survey.

In 2017, a total of 6,619 teachers from the nine states and BIE school participating in DLM science assessments responded to the survey (with a response rate of 84.4%) for 14,991 students (DLM Consortium, 2018a). In 2018, a total of 11,542 teachers from states participating in DLM science assessments and were assigned the science survey block, responded to the survey (with a response rate of 78.7%) for 24,431 students (DLM Consortium, 2018b). In both years, teachers most frequently reported having 0 to 5 years of teaching experience in science and with students with significant cognitive disabilities. The median response to the number of years of experience in both of these areas was 6 to 10 years. Also in both years, more than half of teachers indicated that they had experience administering DLM science assessments in all of the previous operational years (DLM Consortium, 2018a, DLM Consortium, 2018b).

DLM science alternate assessment. The DLM science alternate assessment measures students' knowledge, skills and understandings within three science domains: physical science, life science and earth and space science. The assessment content is aligned to the EEs which provide access to grade-level standards at three levels of cognitive complexity, known as linkage levels. The target linkage level most closely aligns to the grade-level performance expectation while the precursor and initial linkage levels represent the content at a reduced depth, breadth and complexity. Two to four EEs within each science domain are assessed depending on the grade band.

Prior to assessment administration, teachers complete a survey known as the First Contact survey for each of their students. The purpose of the First Contact survey is to collect information about students' expressive communication and academic skills that is subsequently used to assign students to assessment content that most closely aligns to their knowledge, skills and understandings. Using the First Contact information, the system assigns students to one of four bands, known as a complexity bands, which differentiates students with respect to their expressive communication and science academic skills and can be used as a proxy for students' level of knowledge, skills and understandings. For operational purposes, complexity bands are then used to assign the linkage level of the first testlet.

During assessment administration students are administered one testlet per EE at one linkage level. Between testlets, linkage levels can adapt up or down depending on student performance on the previously tested EE. The complexity bands, linkage levels, and adaptive administration are all designed to maximize students' opportunity to demonstrate what they know and can do on content standards aligned to grade-level expectations.

After administration students' responses to assessment items are scored using a diagnostic classification model (DCM) to produce a probability that the student mastered each linkage level. Using a specified threshold in combination with additional scoring rules (see DLM Consortium, 2017 for more information), a mastery status (master or non-master) is assigned to linkage levels within each EE for each student. The number of linkage levels mastered is summed within each domain and represents the number of skills the student has mastered within each domain. Reliability coefficients for domain-level results range from 0.694 to 0.999 (DLM Consortium, 2018b).

The spring 2017 and 2018 science assessments were administered to 19,686 students in nine states and one Bureau of Indian Education (BIE) school and 33,935 students in fourteen states and one BIE school, respectively. In 2017, the assessments were administered by 7,841 educators in 5,577 schools and 1,925 school districts across the participating states. In 2018, the DLM science assessments were administered by 14,262 educators in 8,246 schools and 3,104 school districts.

Table 1 displays the demographic characteristics of students who participated in the spring 2017 and 2018 science assessments. In both years, the majority of participants were male (65% and 67%), white (63% and 60%), and not of Hispanic ethnicity (86% and 81%; DLM Consortium, 2018a and DLM Consortium, 2018b). The demographic characteristics of students who had a completed teacher survey were representative of the population of students who participated in the science assessment.

[Table 1]

Data files for analysis. For each year, the DLM science assessment performance data (including students' assigned complexity band) was merged with the teacher survey data and cleaned for subsequent analyses. First, only students who had results from the science assessment and whose teacher completed the spiraled survey block that was specific to science IT. Cases were also removed if teachers did not respond to all of the questions on the survey related to science IT (n = 170). Furthermore, only states who participated in DLM science in both 2017 and 2018 were included so that comparisons of IT across years were based on the same group of participating states. Students from three states who did not participate in the DLM science assessments in 2017 were removed from the 2018 data sources. Table 2 displays the number of students included in the final datasets by student complexity band.

While the distributions of students across complexity bands were approximately the same across years, there were more students overall in the 2017 data file. There were two factors that contributed to this difference. First, while in 2017 there were fewer science states in the DLM consortium, to ensure adequate participation in the science survey block, the assignment criteria stated that if a student was assigned to take a science test, then assign the science block. In 2018, several states (including one large state) joined the science consortium; thus, the science survey block was assigned randomly (as long as the student was assigned to a science test) among all possible blocks. Moreover, additional spiraled blocks were added to the teacher survey thereby decreasing sample sizes overall for any given block.

[Table 2]

Data Analysis

To answer the first research question, responses from the teacher survey were used to summarize science IT by science domain and SEP. A numeric value was assigned to each point on an ordinal scale: 1 = none, 2 = 1-10 hours, 3 = 11-20 hours, 4 = 21-30 hours, or 5 = more than 30 hours. In 2017, teachers provided an estimate of IT at the domain-level in the teacher survey. In 2018, they provided an estimate of IT for each science core idea within a domain; therefore, the assigned numeric values were used to calculate the median amount of IT for each science domain from teacher responses at the core idea level. The median represents the central tendency for ordinal data. Since not all core ideas are assessed at each grade band, only assessed core ideas were included in the median calculation[1]. If a domain had an even number of core ideas associated with it, the median was rounded up to the nearest integer. To evaluate if the amount of IT provided by teachers was different by domain or SEP, the percentage of teachers who selected each category of IT was calculated. Patterns in frequency distributions of reported IT are compared across two years of survey data.

To address the second research question, correlational analyses were conducted to evaluate the relationship between IT and student science achievement for 2017 and 2018. Within the 1% population of students who take alternate assessments, there is significant variability in students' knowledge, skills and understandings. For example, students in the lowest complexity band may not yet use words to communicate, while students in the highest complexity band communicate with two or more words at a time. As some students may require more instruction to achieve the same or even a lower level of skill mastery as other students eligible for alternate assessment, the relationship between IT and student achievement was analyzed for each complexity band.

Again, the amount of IT students received by domain and SEP came from the 2017 and 2018 teacher surveys and the median amount of IT across core ideas within domains was used for the 2018 data. Student achievement was measured by the 2017 and 2018 DLM science assessment which provides the number of linkage levels mastered within each science domain. Spearman rank-order correlations between domain IT and domain linkage levels mastered, as well as between the median IT for all SEPs and total linkage levels mastered summed across all domains, were calculated by complexity band for each year and are interpreted using Cohen's

[1] One life science core idea (LS3) is only assessed in end-of-instruction biology which is not included in this study; LS4 is only assessed in high school; one earth and space science core idea (ESS1) is not assessed in middle school while another (ESS2) is only assessed middle school.

guidelines (1988). Confidence intervals were calculated using a Fisher's z transformation of the correlation, plus or minus 1.96 times the standard error which is estimated by $1/\sqrt{n-3}$ (see Bonnet & Wright, 2000). It was hypothesized that positive but small to moderate relationships between amount of domain-level IT and number of linkage levels mastered in the domain would be found. Strong correlations were not expected given that for some students in this population, such as those with the most significant disabilities, large amounts of instructional time may translate to mastery at only the lowest linkage level, which results in a small achievement gain of one domain linkage level. While this is considered to be important progress, it may attenuate the overall strength of the relationship between IT and student achievement.

To answer the first research question, the percentage of teachers who selected each category of IT for each domain and SEP was calculated. Figures 1 displays the percentage of teachers who reported instructing students for zero, 1-10 hours, 11-20 hours, 21-30 hours and more than 30 hours per year in each science domain in 2017. Figure 2 displays the percentage of teachers whose median response category across core ideas was zero, 1-10 hours, 11-20 hours, 21-30 hours and more than 30 hours per year in each science domain in 2018. In both years, the most frequent response was 1-10 hours followed by 11-20 hours.

[Figure 1]

[Figure 2]

Figures 3 and 4 display the percentage of teachers who reported instructing students in each SEP in 2017 and 2018, respectively. Similar to the domain findings, the most commonly selected response for the SEPs was 1–10 hours. In 2018, slightly more teachers selected 1-10 hours of IT for each SEP; there did not appear to be any other noticeable shifts across years in the other response options.

[Figure 3]

[Figure 4]

To answer the second research question, Spearman rank-order correlations between IT for each domain and number of linkage levels mastered within the domain were calculated for each year. Table 3 shows the results of the correlation analyses. As expected, the correlations were positive but small for most domains and complexity bands. Negligible correlations were observed for Band 1 students in physical science and Band 3 students in all three science domains. Across years, the domain-level correlations appeared to be stronger in 2017 in comparison to 2018; however, the confidence intervals for each set of domain-level correlations overlapped indicating that they were not different from one another. There did not appear to be a consistent pattern of correlations for complexity bands across years.

[Table 3]

Finally, Spearman rank-order correlations between the median reported IT for all SEPs and the total number of linkage levels mastered summed across all three science domains was calculated for each year. For 2017, the correlation was .319 ($p < .01$) and in 2018 it was .211 ($p < .01$), suggesting small to moderate relationships. For both years the SEP correlations were somewhat stronger than the corresponding domain-level correlations suggesting that there may be a stronger connection between student skill mastery and IT on SEPs than IT on domain-specific content.

Discussion

The amount of IT delivered to students with SCD varied by science domain, but variations by domain were relatively small. Across domains and in both years, the most frequent response was spending 1 to 10 hours of instructional time, followed by 11 to 20 hours. This supports that the distribution of IT by domain was similar in 2017 and 2018. However, in both 2017 and 2018, some teachers indicated they had spent zero hours of instructional time for specific science domains, which was surprising. This result indicates that teachers may need training and/or support to provide the content instruction that is aligned with states' science content standards for students with significant cognitive disabilities.

Surprisingly, a slightly larger percentage of teachers indicated that they did not spend any time instructing on science content in 2018 than in 2017 and a smaller percentage of teachers selected 21-30 or more than 30 hours in 2018. These unexpected shifts may reflect a difference in the size of the time categories used across the two years of data collection. In 2018, smaller (i.e., topic vs. domain) content categories were used with the same time categories (i.e., 1-10 hours). Teachers in 2018 may have provided as much instruction within the domains but may the size of the time categories may. have prevented accurate capture of these data.

The amount of IT delivered to students with SCD varied by SEP. Similar to the domain findings, the most commonly selected response was 1 to 10 hours. The second most commonly selected response was either 11 to 20 hours or zero hours depending on the SEP. In 2017 and 2018, 11 to 20 hours of IT was indicated more frequently than zero hours for four SEPs (i.e., Planning and Carrying Out Investigations, Analyzing and Interpreting Data, Using Mathematics and Computational Thinking, and Obtaining, Evaluating, and Communicating Information). Zero hours was indicated more frequently than 11 to 20 hours for two SEPs in 2017 and 2018 (i.e., Constructing Explanations and Designing Solutions and Engaging in Argument from Evidence) and for one additional SEP in 2018 (i.e., Developing and Using Models). This suggests that the distribution of IT by SEP was similar for most SEPs in 2017 and 2018, but different for one SEP. In both years, some teachers reported zero IT for specific SEPs, which was surprising. This is similar to what was identified for IT by domain, and indicates that teachers may need training and/or support to provide students with significant cognitive disabilities instruction that is aligned with the states' science content standards. A consistent trend observed in the 2017 and 2018 data was the higher percentages of teachers reporting zero hours of instructional time for the three SEPs of Engaging in Argument from Evidence, Constructing Explanations and Designing Solutions, and Developing and Using Models than for other SEPs. This indicates that these three SEPs are a particular area of need for teacher training and support.

The correlations between IT and achievement in science for students with SCD were small and positive, which is similar to those of general education students (Blank, 2013; Lavy, 2015). According to Floden (2002), three decades of studies support a positive association between OTL and student achievement. However, different methods of measuring OTL have yielded different correlations with student achievement. The largest student-level correlations were found when content was represented at a high level of detail and included the distribution of time across tested topics. Small, positive correlations between topic IT and student achievement have been found in content domains. However, the analyses employed in the present study used the domain level and included the distribution of time across domains rather than topics, which could result in lower correlations. Different measures with greater detail regarding topics and time across topics could yield stronger correlations. Floden (2002) suggested that stronger relationships would likely be captured when IT is measured for specific topics, but he also warned of increased burden on teacher respondents. For example, some studies have used weekly teacher reports of IT by topic (e.g., Fisher et al., 2015).

Many factors beyond how IT is measured can also affect the relationship between IT and achievement. For example, Floden (2002) attributed variations in the strength of association to low variations in IT among schools, reliability of teacher self-reported IT, contributions of learning outside school, or transfer of learning between topics. These factors were not investigated in the present study. In the present study, differences in learning rates associated with the characteristics of students who were in the different complexity may have contributed to the relationship between IT and domain linkage levels mastered. The cognitive characteristics of students in these complexity bands mean that complexity band membership was likely associated with different degrees of student response to the same amount of IT. Furthermore, the cognitive demands of the assessments vary with complexity band, which may mean that for a given student, more IT would be required to master higher linkage levels. However, overlapping confidence intervals for the correlations obscured any such differences.

Properties of the achievement measure may also have affected the strength of the relationships between IT and achievement. The achievement measure is a sum of the linkage levels mastered, which increases by a different amount for testlets mastered at different linkage levels. For example, one linkage level was gained for successfully completing a testlet at the lowest complexity band, while two or three linkage levels were gained for successfully completed a testlet at the higher complexity bands. This means that successful completion of a single testlet has a different effect on the achievement measure, depending on the complexity band. This difference may affect the strength of the association between IT and domain linkage levels mastered

One limitation of this study was the method for measuring science IT. Year to year trends in instructional time were more difficult to identify due to changes in the survey items between years. In 2017, teachers estimated IT at the domain level (i.e., physical, life, earth and space), while in 2018 teachers estimated IT for each DCI within each domain. It may be that teachers reported more hours on a domain level when they reported data aggregated across topics, but reported fewer hours when they reported data in each specific core idea. Alternately, it may be that the DCI descriptors were not as well understood by teachers as the domain names and resulted in underreporting of IT. Future studies of IT should include refinements of the teacher survey instrument to improve reliability. Floden (2002) suggested that researchers put more efforts into the development of OTL measures to increase reliability. In particular, he recommended the careful development of topic categories through testing and revision. Future work could possibly investigate teachers' interpretations of the topic categories to improve the measure of science IT.

The results inform stakeholders, policy makers, and researchers about progress in shifting to a science curriculum for students with SCD that includes the domains, DCIs, and SEPs in the NGSS. Specifically, the results describe the science IT that is typically provided to students with SCD in the consortium and the relationship of IT to those students' science achievement. These findings can inform policy makers' decisions about progress made in recent changes to curricula for students with SCD, professional development needs for special educators, and inform the future development of curricular support for teachers of students with SCD that meet their needs. Results could help educators move the field forward in thinking about providing this population of students more exposure to and opportunity to learn science, particularly the SEPs that have been identified as having the lowest IT. As demonstrated by general education students (Blank, 2013; Levy, 2015), more and richer opportunities to learn science can improve a range of outcomes, including increased achievement, college and career readiness, and self-determination.

Limitations to these findings include that growth in OTL is constrained by the availability of appropriate preservice and inservice training (Sindelar et al., 2010) or curricular supports that are aligned to the new curriculum, as well as the prevalence of teacher attitudes that may favor the provision of functional over academic curricula for these students (e.g., Ayres et al., 2011). Instructional supports are currently in development to support teachers using DLM and as they become more available and teacher thinking changes, OTL should increase accordingly. Needless to say, more work is needed to think openly and innovatively about how to provide students with SCD opportunities to learn science in ways that are not only accessible but also meaningful and translate to higher levels of achievement, self-determination, science literacy, and real-world life skills.

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Table 1

Demographic Characteristics of Students Participating in 2017 (n=19,686) and 2018 (n=33,935) Science Assessments

Subgroup	**2017**		**2018**	
	n	**%**	***n***	**%**
Gender				
Female	6,866	34.9	11,315	33.3
Male	12,816	65.1	22,618	66.7
Missing	4	0.0	2	0.0
Race				
White	12,371	62.8	20,418	60.2
African American	3,893	19.8	7,916	23.3
Asian	635	3.2	1,626	4.8
American Indian	624	3.2	954	2.8
Alaska Native	106	0.5	89	0.3
Two or more races	1,961	10.0	2,744	8.1
Native Hawaiian or Pacific Islander	66	0.3	167	0.5
Missing	30	0.2	21	0.1
Hispanic Ethnicity				
No	17,014	86.4	27,455	80.9
Yes	2,606	13.2	6,459	19.0
Missing	66	0.3	21	0.1

Table 2

Number and Percent of Students by Complexity Band

	2017		2018	
Complexity Band	**n**	**%**	**n**	**%**
Foundational	469	16.3	193	16.1
Band 1	1010	35.1	434	36.2
Band 2	931	32.4	356	29.7
Band 3	465	16.2	216	18.0
Total	2,875	100.0	1,199	100.0

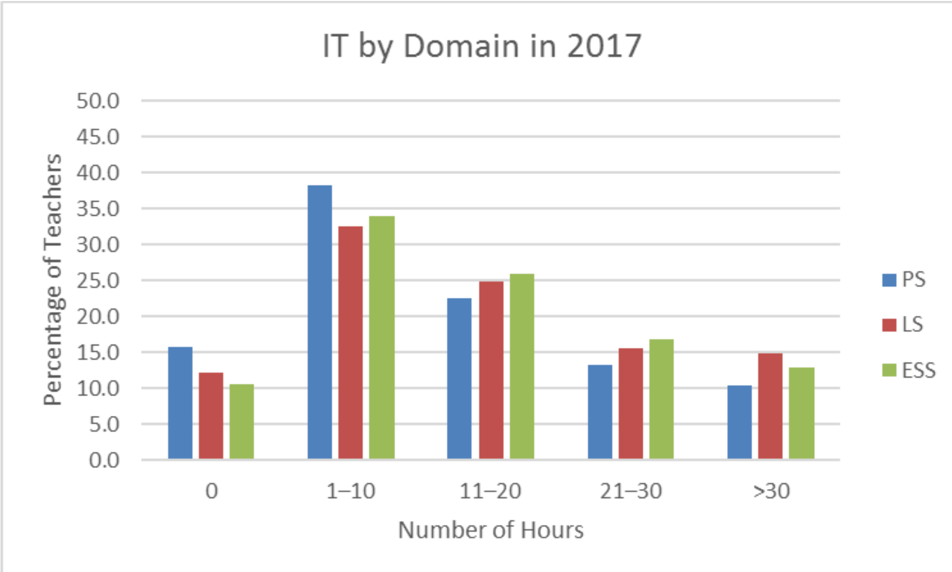

Figure 1. Amount of instructional time spent on science domains during the 2016-2017 academic year
Note. PS = Physical Science; LS = Life Science; ESS = Earth and Space Science

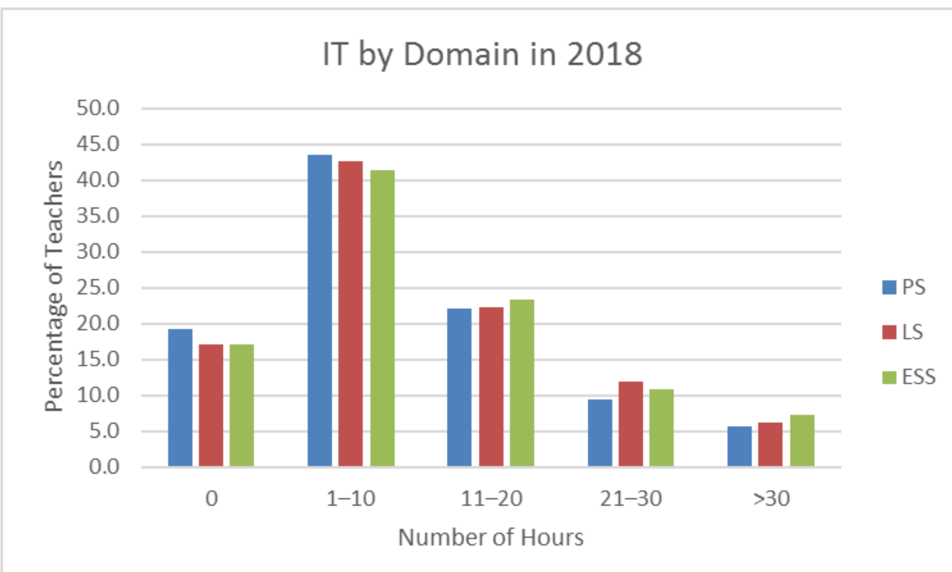

Figure 2. Amount of instructional time (median within domain topics) spent on science domains during the 2017-2018 academic year
Note. PS = Physical Science; LS = Life Science; ESS = Earth and Space Science

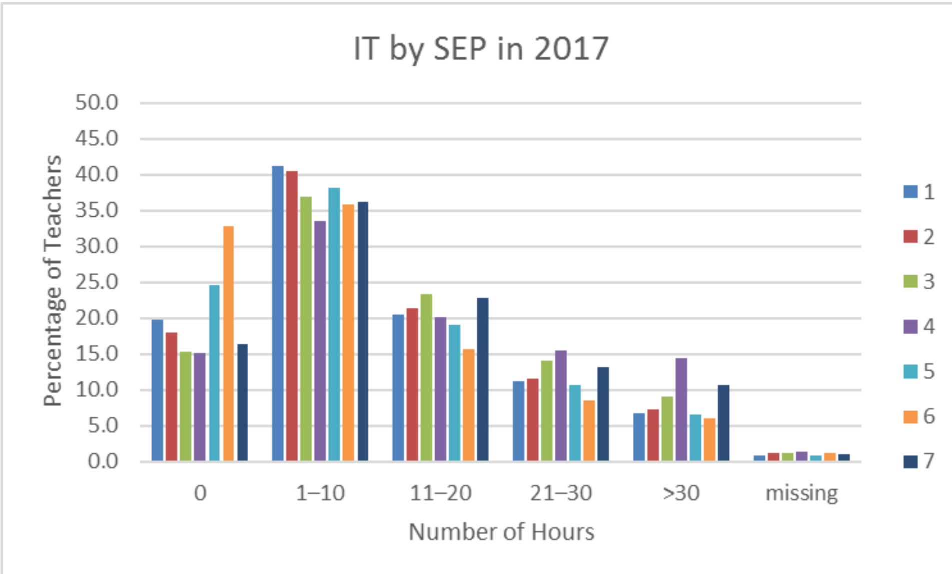

Figure 3. Amount of instructional time (IT) spent on SEPs during the 2016-2017 academic year.

Note. 1 = Developing and Using Models; 2 = Planning and Carrying out Investigations; 3 = Analyzing and Interpreting Data; 4 = Using Mathematics and Computational Thinking; 5 = Constructing Explanations and Designing Solutions; 6 = Engaging in Argument from Evidence; 7 = Obtaining, Evaluating, and Communicating Information

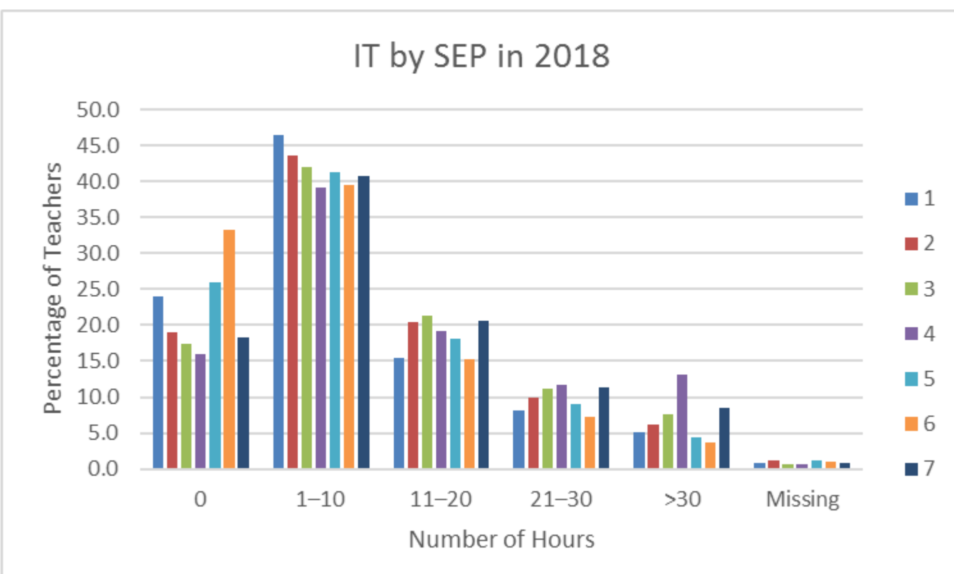

Figure 4. Amount of instructional time (IT) spent on SEPs during the 2017-2018 academic year.

Note. 1 = Developing and Using Models; 2 = Planning and Carrying out Investigations; 3 = Analyzing and Interpreting Data; 4 = Using Mathematics and Computational Thinking; 5 = Constructing Explanations and Designing Solutions; 6 = Engaging in Argument from Evidence; 7 = Obtaining, Evaluating, and Communicating Information

Table 3

Correlations Between IT and Domain Linkage Levels Mastered by Complexity Band

Domain	2017		2018	
	ρ	CI	ρ	CI
Physical Science	.207**	.173 – .245	.126**	.069 – .184
Foundational	.142**	.050 – .236	.212**	.071 – .360
Band 1	.219**	.160 – .286	.073	-.022 – .169
Band 2	.141**	.076 – .208	.121**	.016 – .227
Band 3	.097*	.003 – .191	-.008	-.144 – .128
Life Science	.196**	.161 – .236	.143**	.087 – .201
Foundational	.199**	.108 – .295	.144*	.001 – .290
Band 1	.161**	.099 – .226	.124*	.029 – .220
Band 2	.122**	.057 – .188	.119*	.014 – .225
Band 3	.112*	.018 – .207	.077	-.059 – .213
Earth and Space Science	.212**	.178 – .253	.151**	.095 – .210
Foundational	.233**	.144 – .331	.183**	.041 – .330
Band 1	.183**	.122 – .248	.107*	.012 – .203
Band 2	.170**	.106 – .237	.197**	.094 – .305
Band 3	.173**	.081 – .269	-.001	-.137 – .135

Note. ** p-value < .01; * p-value < .05