NSSME | THE NATIONAL SURVEY OF SCIENCE & MATHEMATICS EDUCATION

Elementary Science Instruction in the US: Warning Signs and Ways Forward

NARST

APRIL 16, 2020

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horizon RESEARCH, INC.

About the 2018 NSSME+

- **The 2018 NSSME+ is the sixth in a series of surveys dating back to 1977.**

- **It is the only survey specific to STEM education that provides nationally representative results.**

The 2018 NSSME+, and this presentation, is based upon work supported by the National Science Foundation under Grant No. DGE-1642413. Any opinions, findings, and conclusions or recommendations expressed are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Topics Addressed

Six different survey instruments

- Characteristics of the science/mathematics/computer science teaching force:
  - demographics
  - preparation for teaching
  - beliefs about teaching and learning
  - perceptions of preparedness
- Instructional practices
- Factors that shape teachers' decisions about content and pedagogy
- Use of instructional materials
- Opportunities teachers have for professional growth
- How instructional resources are distributed

Who's In the Sample

Two-stage random sample that targeted:

- 2,000 schools (public and private)
- Over 10,000 K–12 teachers

Very good response rate:

- 1,273 schools participated
- 86 percent of program representatives
- 78 percent of sampled teachers

Endorsing Organizations

- American Association of Chemistry Teachers
- American Association of Physics Teachers
- American Federation of Teachers
- Association of Mathematics Teacher Educators
- American Society for Engineering Education
- Association of State Supervisors of Mathematics
- Association for Science Teacher Education
- Council of State Science Supervisors
- Computer Science Teachers Association
- National Association of Biology Teachers
- National Association of Elementary School Principals
- National Association of Secondary School Principals
- National Council of Supervisors of Mathematics
- National Council of Teachers of Mathematics
- National Earth Science Teachers Association
- National Education Association
- National Science Education Leadership Association
- National Science Teachers Association

Interpreting Results

After data collection, design weights were computed, adjusted for nonresponse, and applied to the data.

Why should you care?

The sampling and weighting processes mean that the results are national estimates of schools, teachers, and classes—not characteristics of the respondents.

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Several reports and other products are available on our website, including:

- Technical report
- Highlights report
- Compendium of Tables
- Trends report
- Novice teacher report

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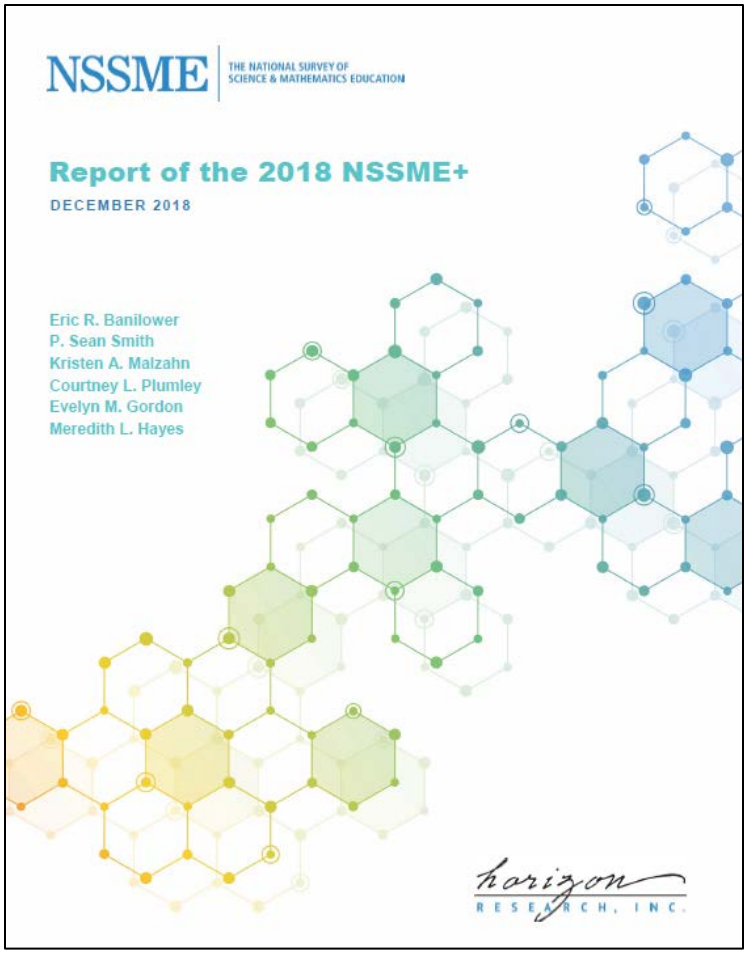

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Trends in Elementary Science Instruction from 2012 to 2018

Eric R. Banilower

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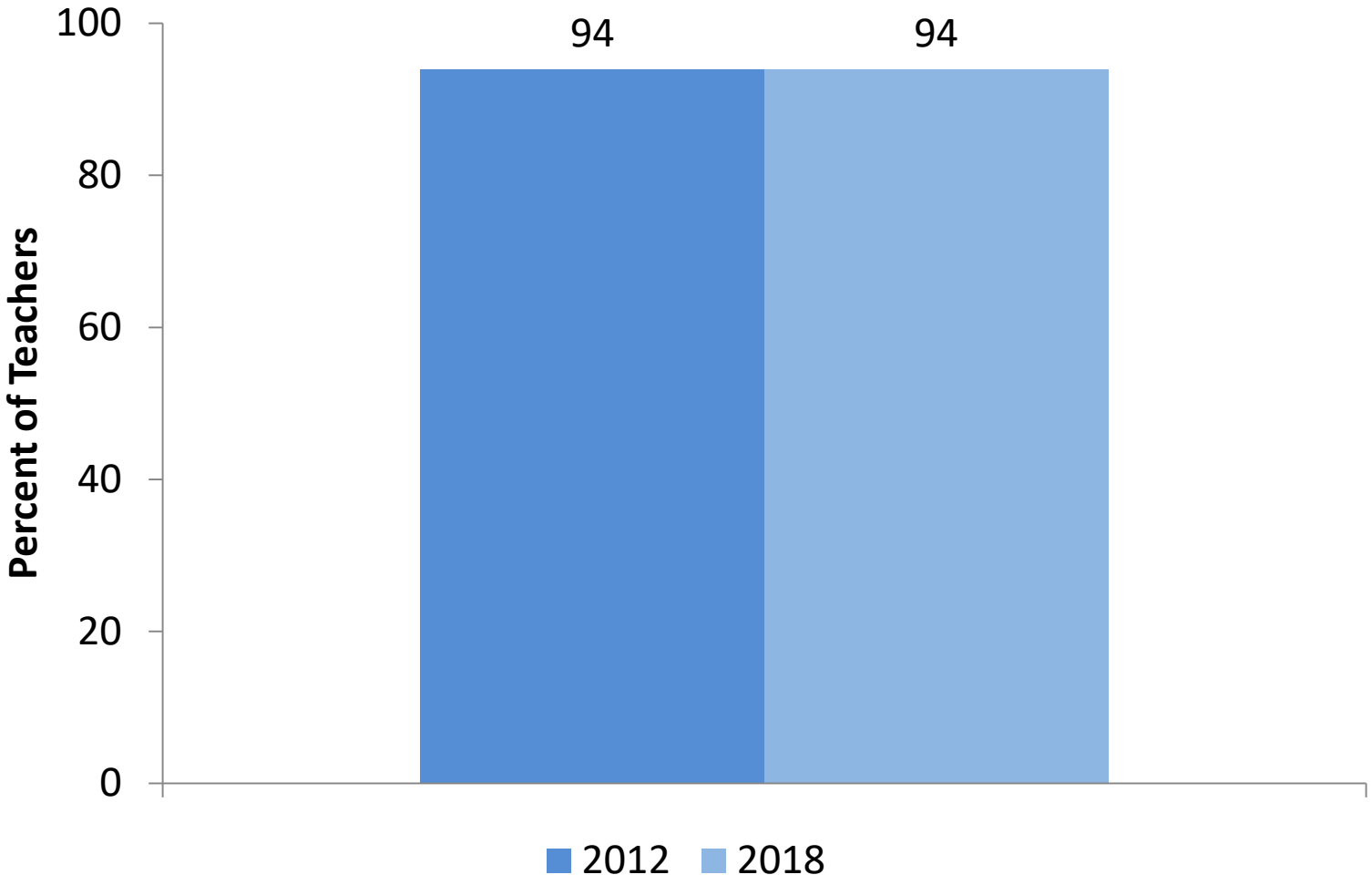
Teacher Characteristics

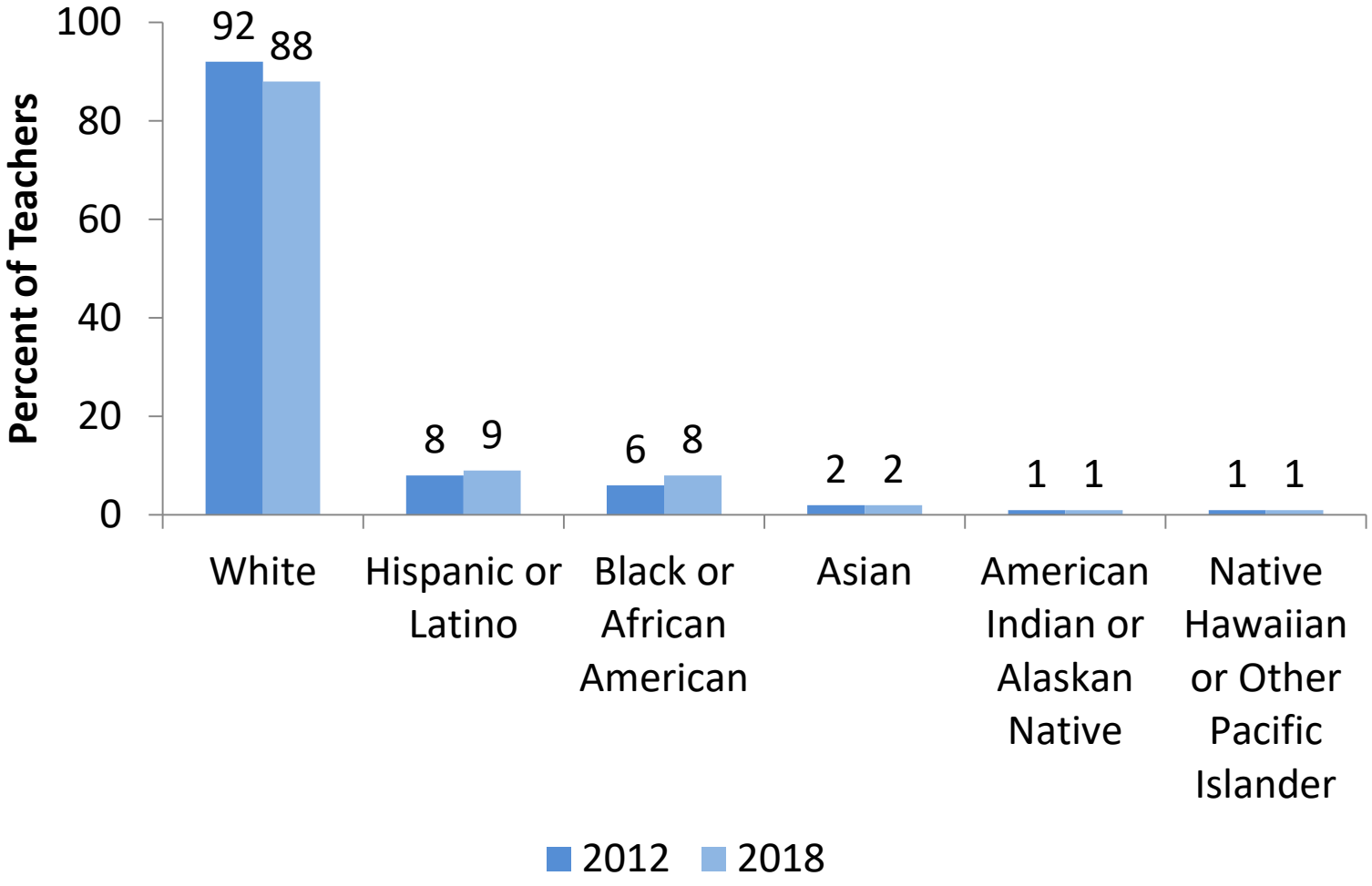
The 2018 NSSME+ collected data on:

- Gender
- Race/ethnicity
- Age
- Years of teaching experience
- Content background (courses and degrees)
- Preparedness
- Beliefs

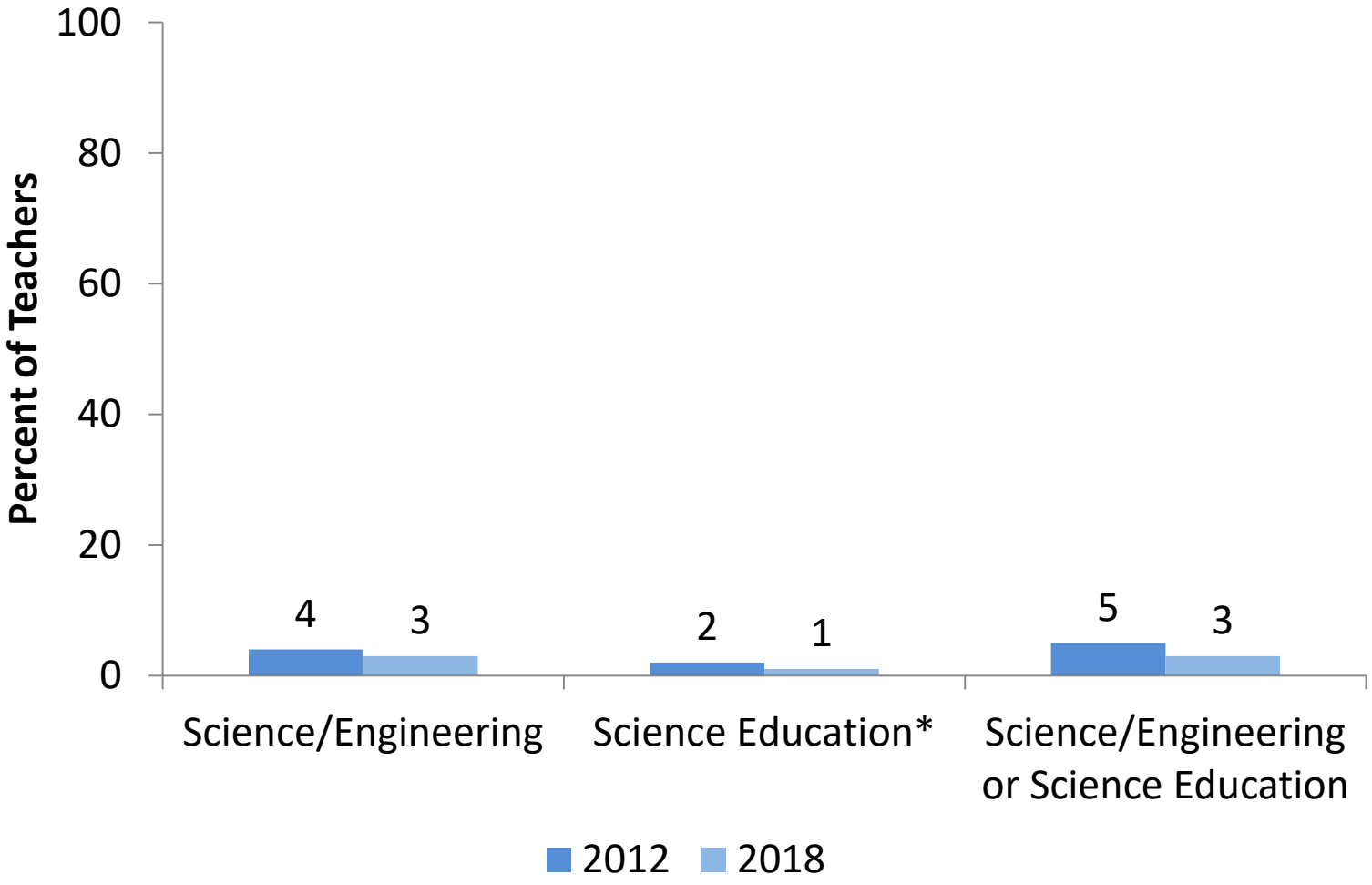
Female Teachers



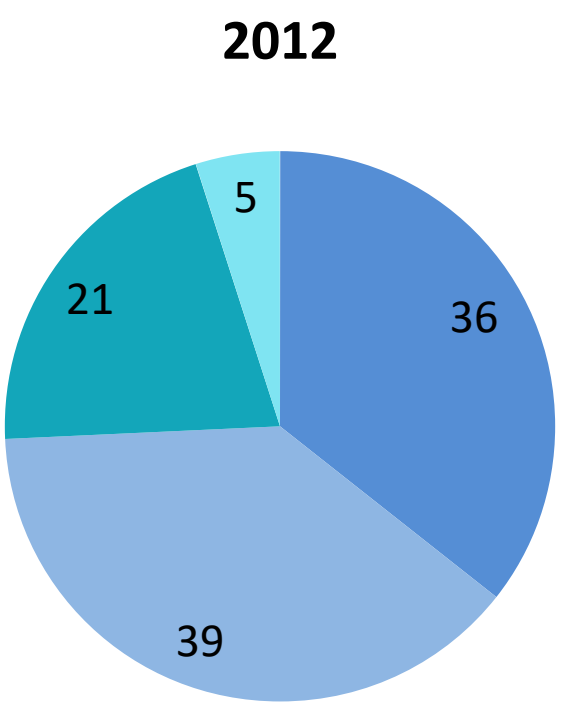
Race/Ethnicity

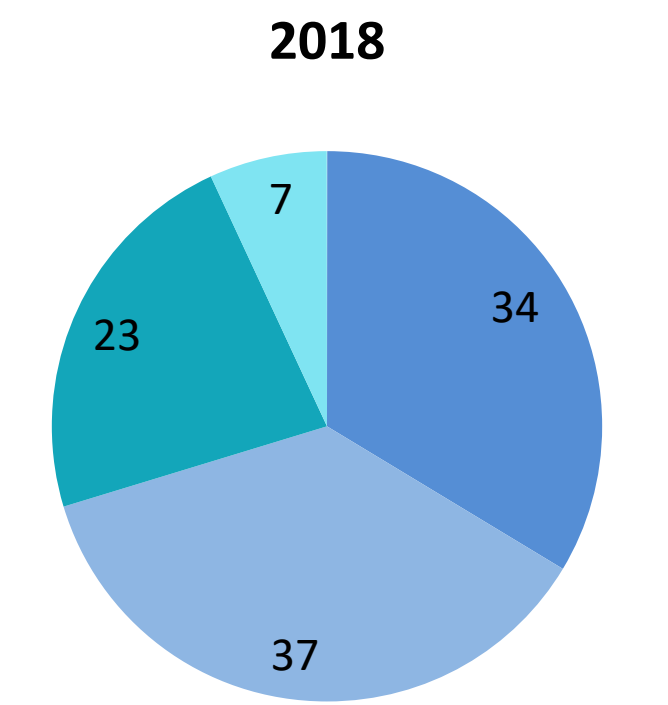


Degrees Earned



College Science Coursework





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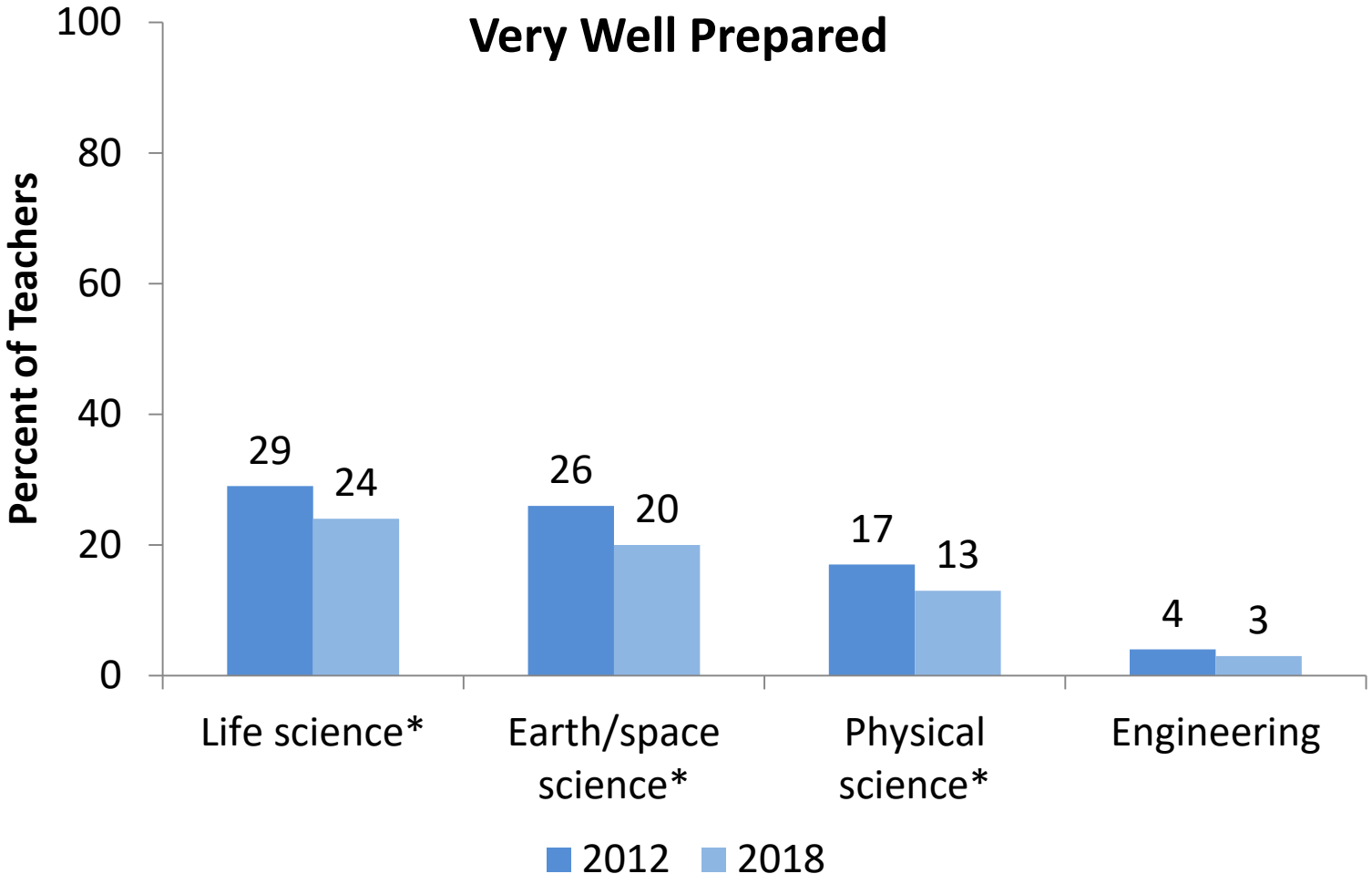
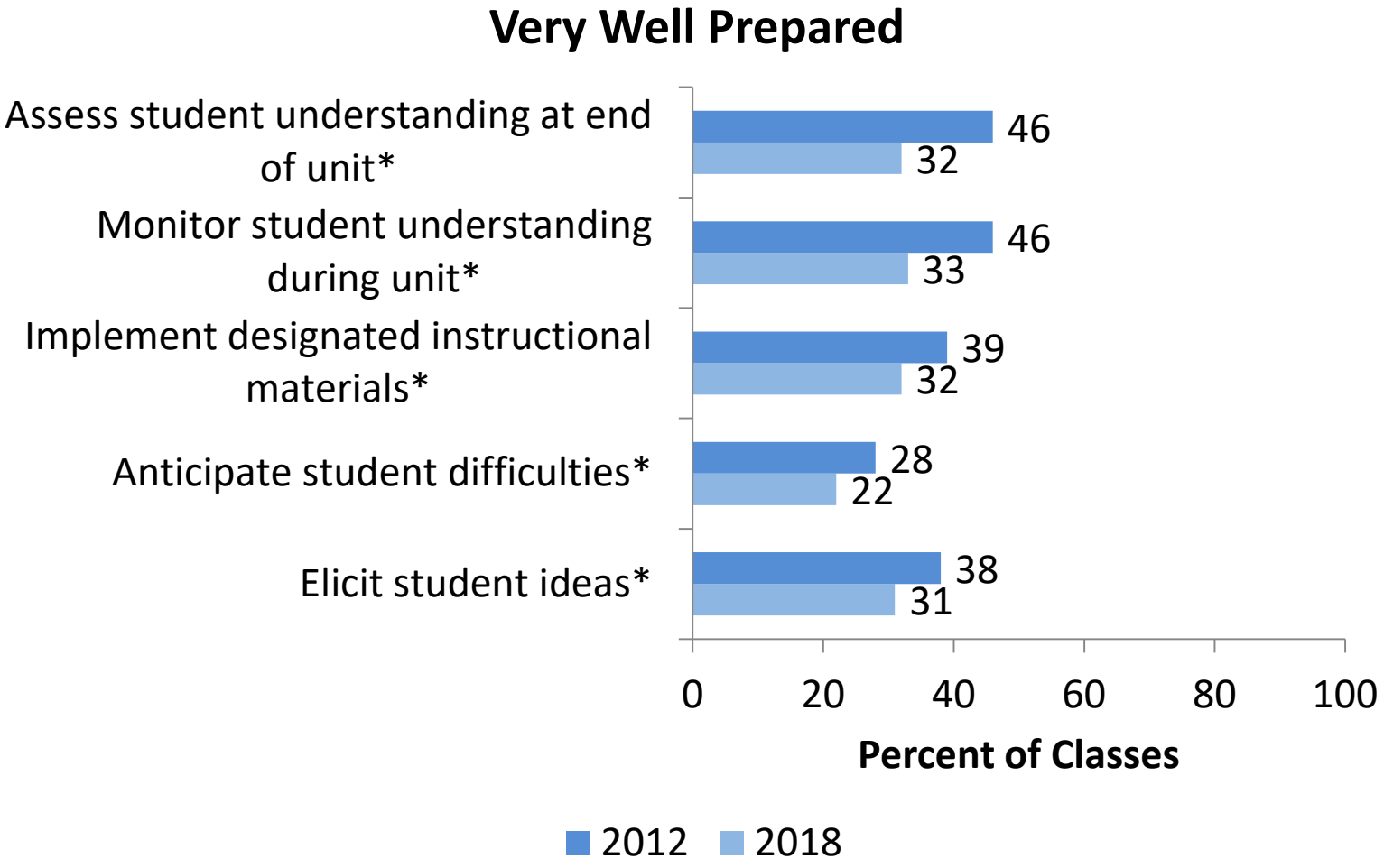
Feelings of Preparedness

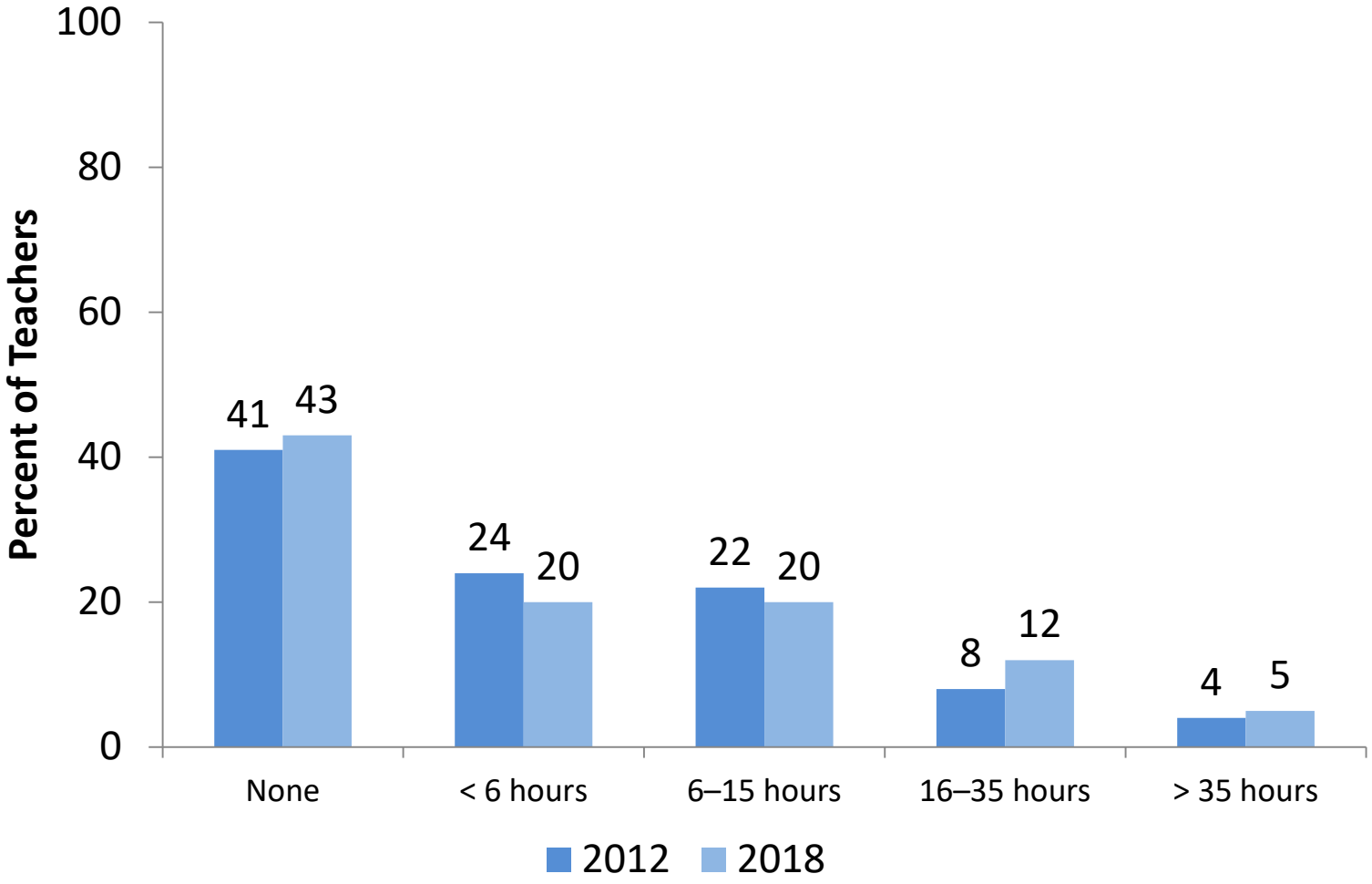


Feelings of Preparedness

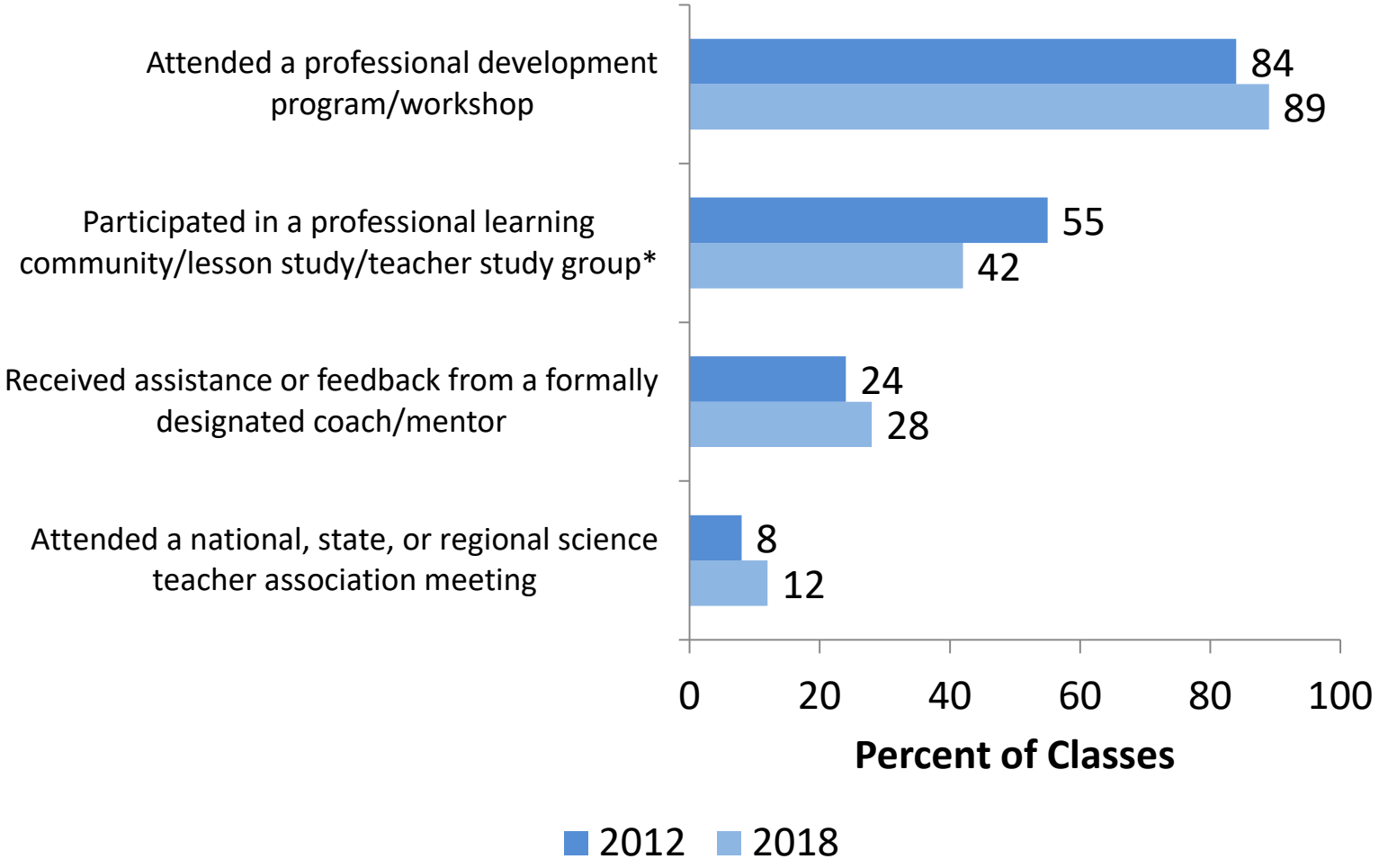


Professional Development

Amount of Science-Related PD in Previous Three Years

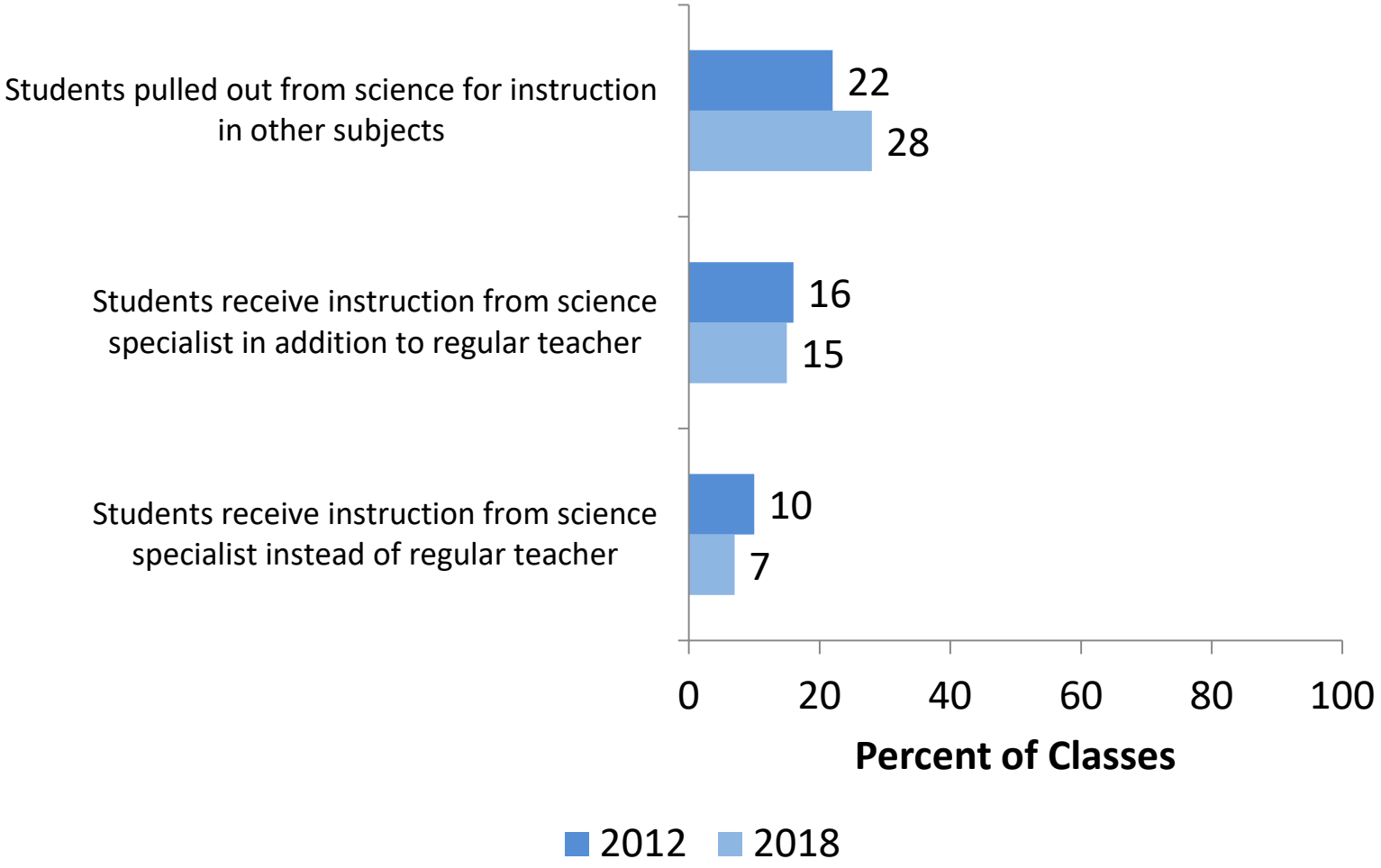


Types of Science-Related PD in Previous Three Years

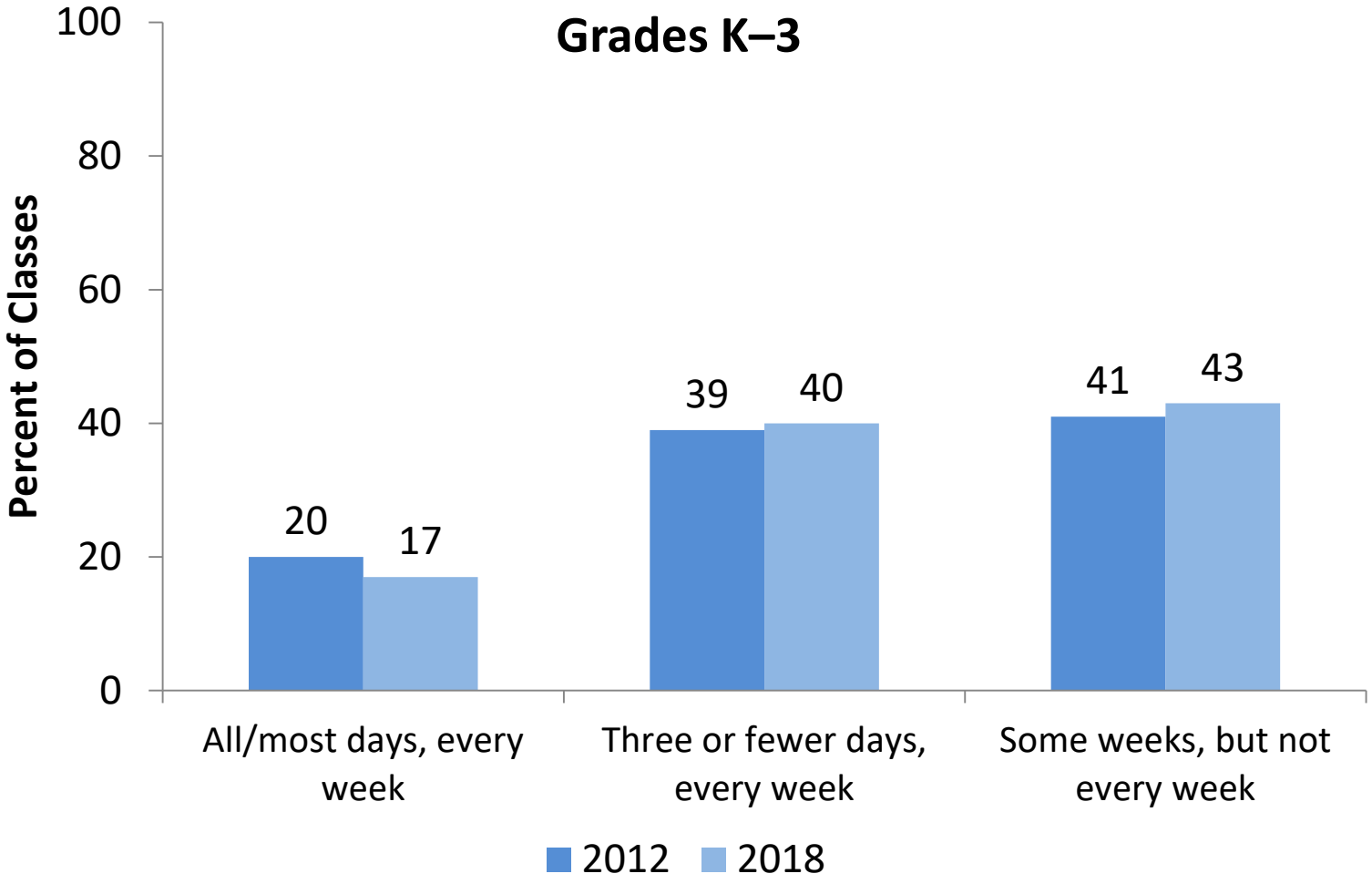


Science Instruction

Instructional Arrangements



Frequency of Science Instruction: Self-Contained Classrooms



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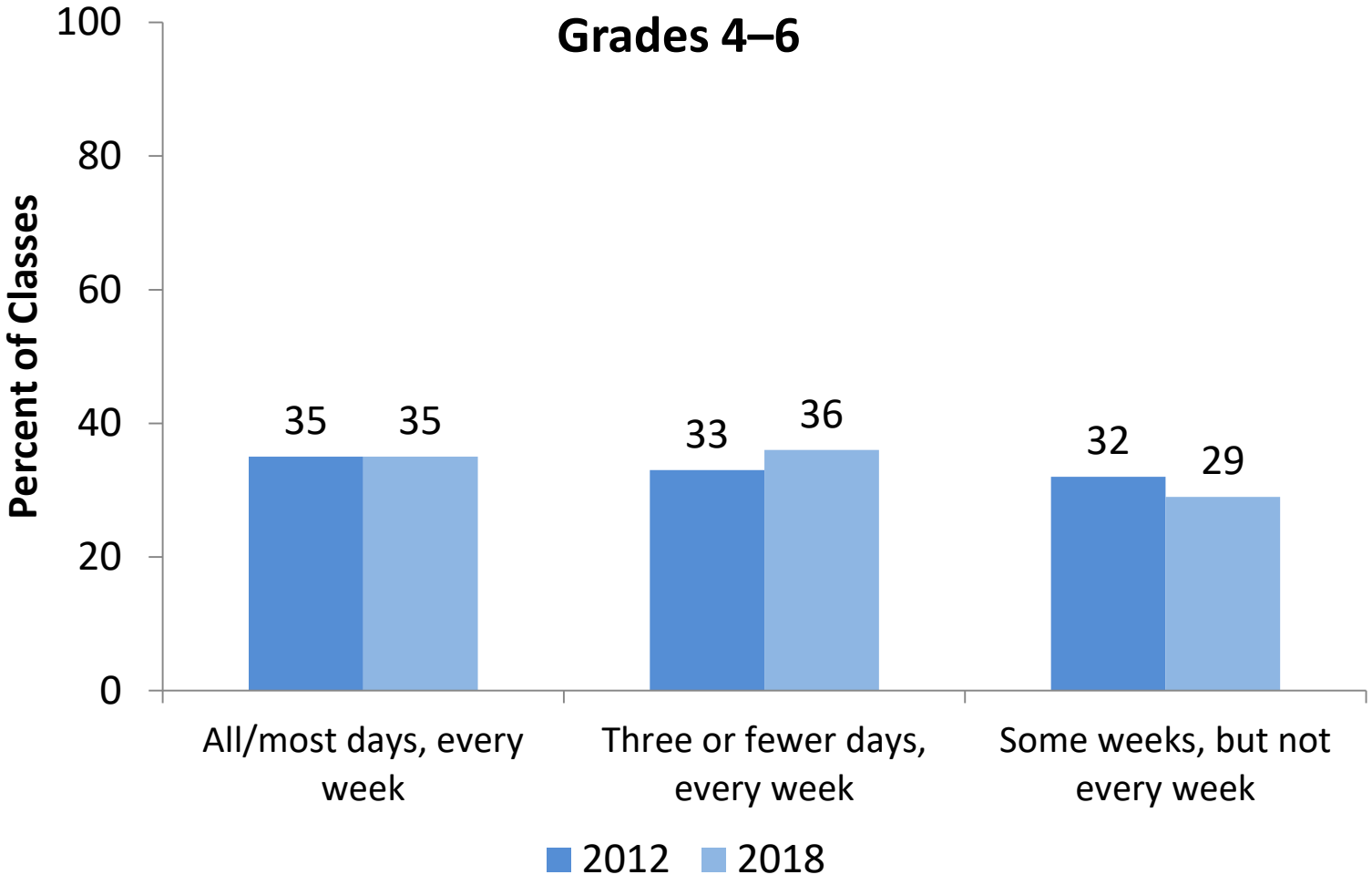
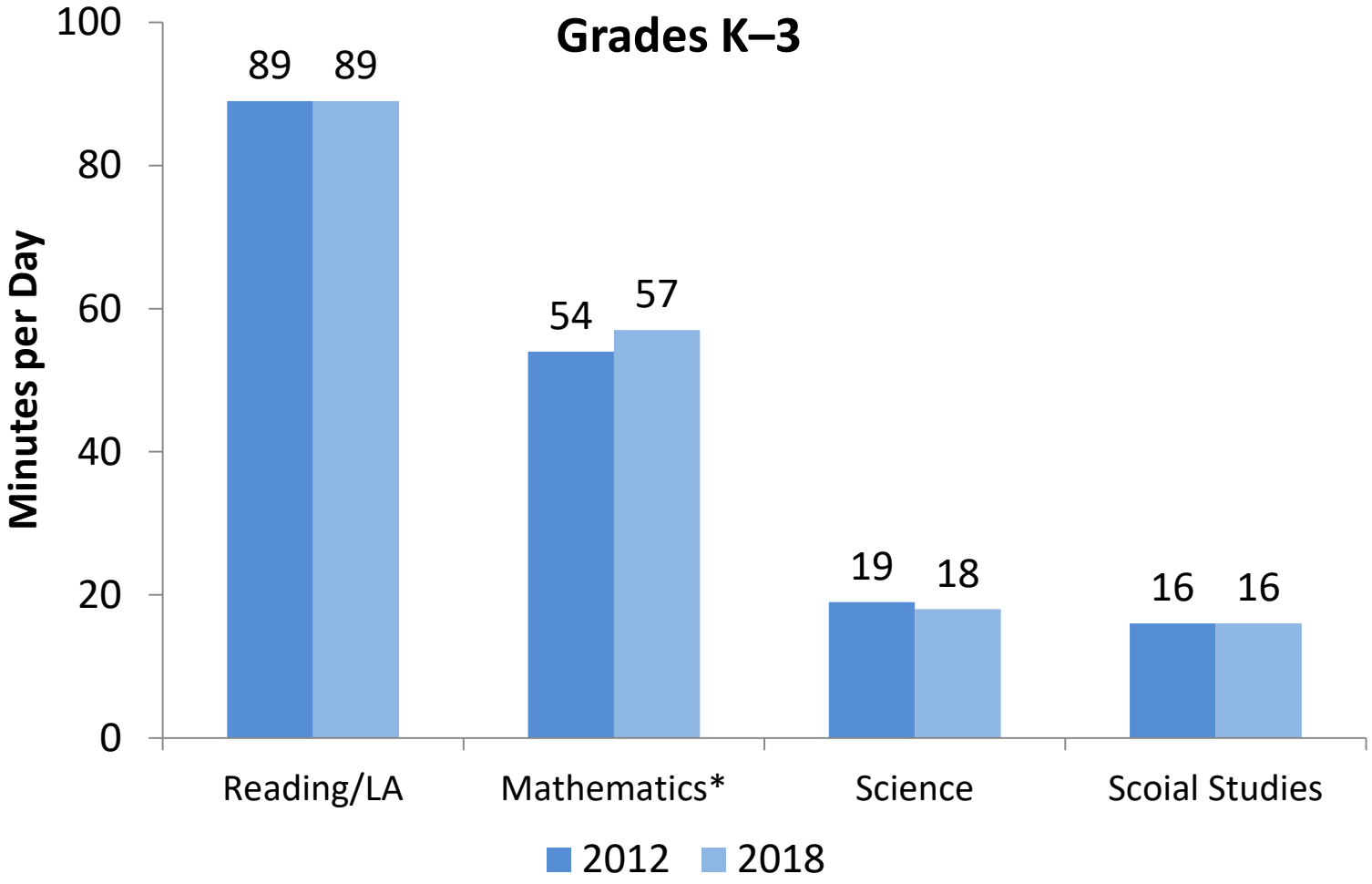


Instructional Time: Self-Contained Classrooms



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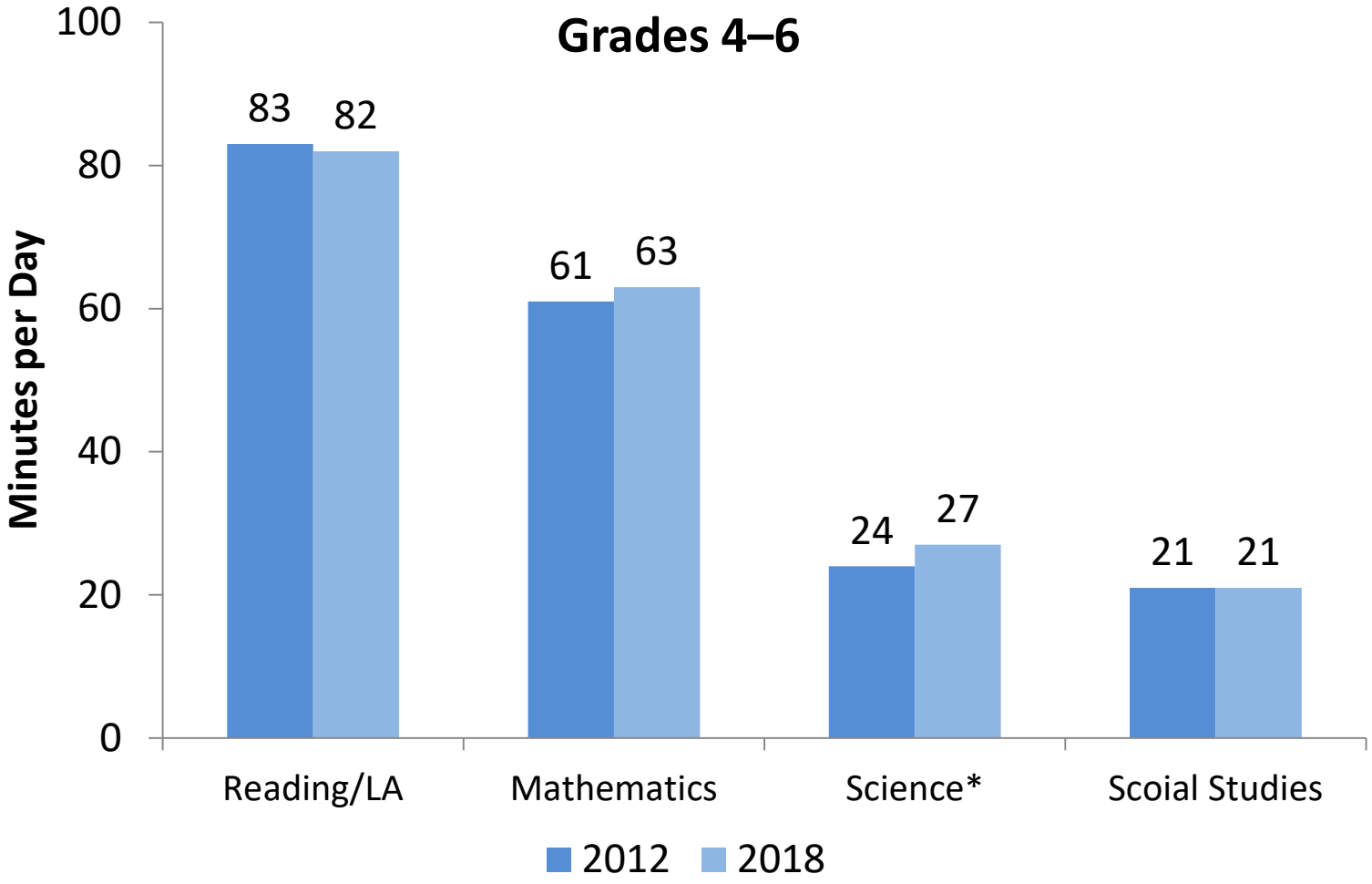
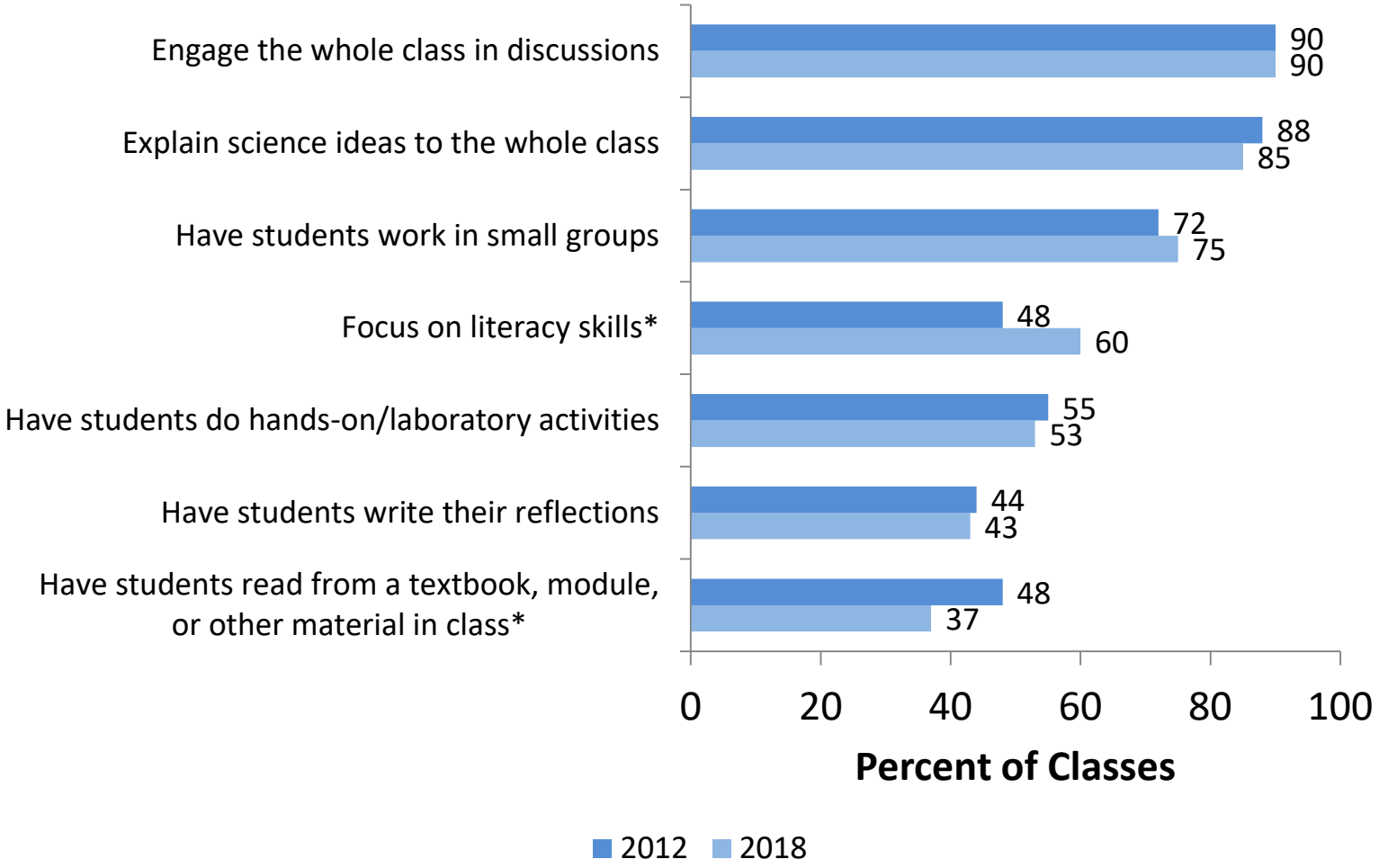
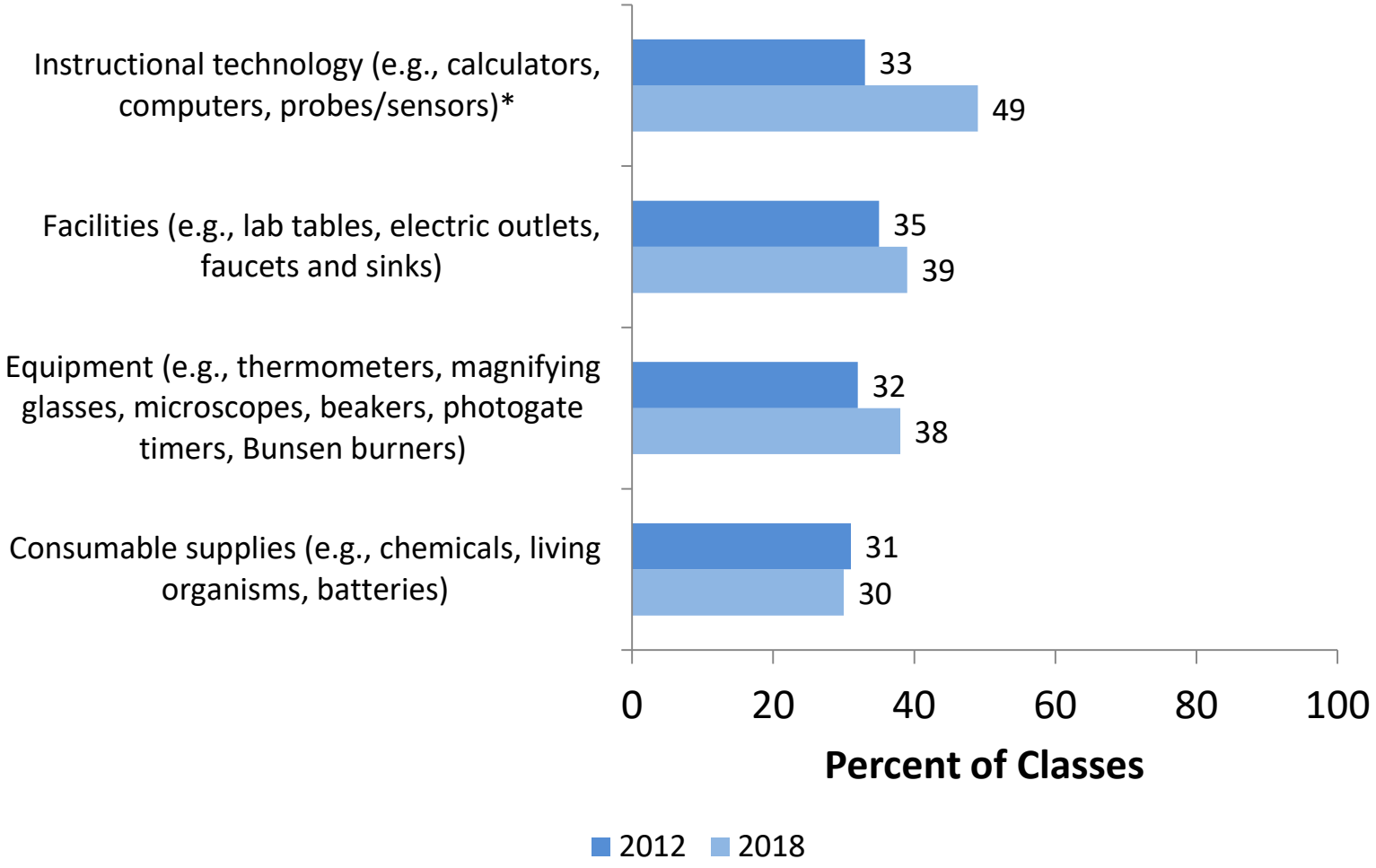


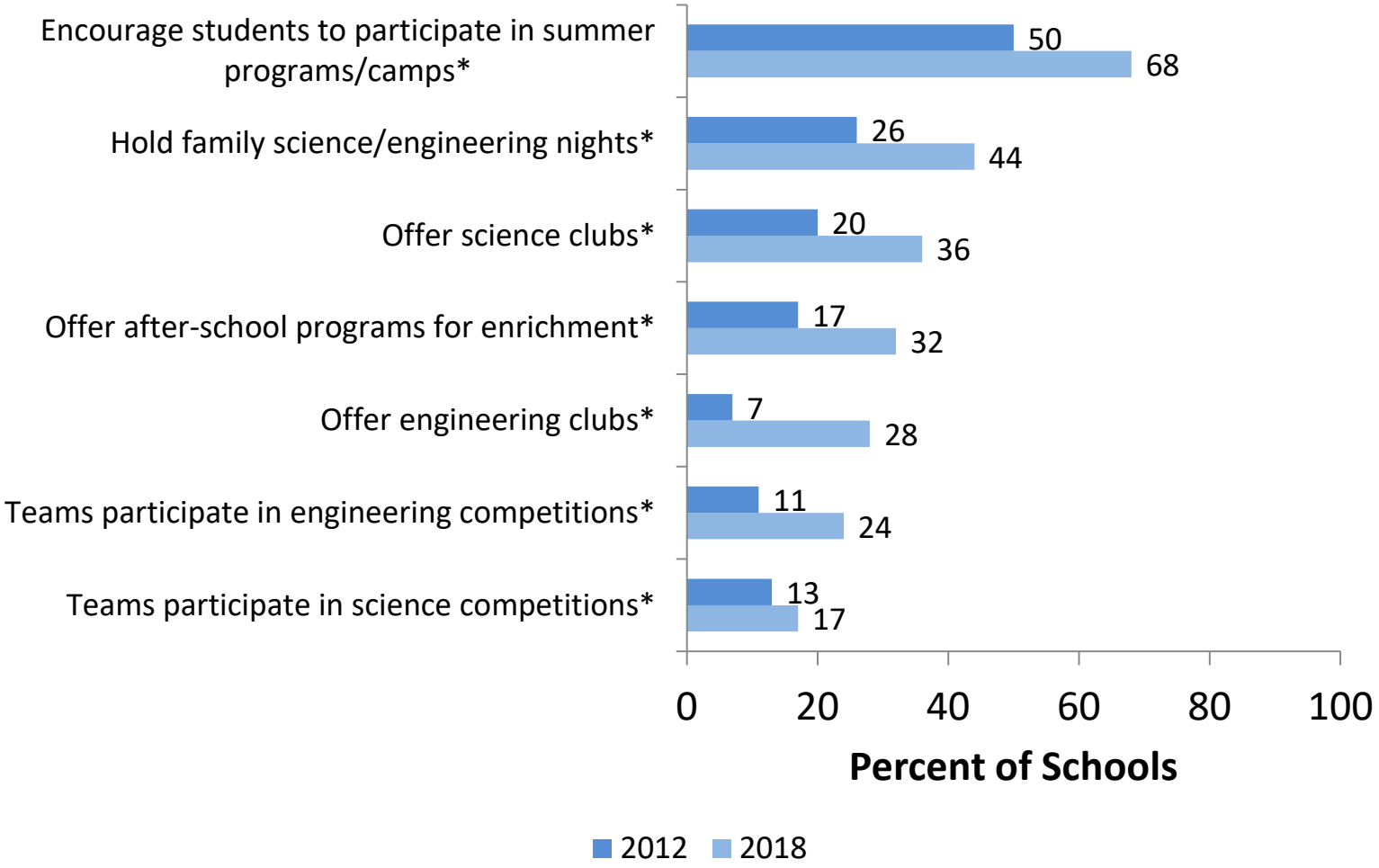
Class Activities: At Least Once a Week



Classes in Which Teachers Feel Various Resources are Adequate



School Science/Engineering Enrichment Programs



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Conclusions

Continued problem areas, including:

- Lack of diversity in teaching force
- Lack of teacher preparation to teach science
- Limited participation in science-related professional learning opportunities
- Limited instructional time devoted to science
- When science is taught, lecture and discussion are the primary pedagogies used

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Novice Elementary Science Teachers

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Novice Elementary Science Teachers

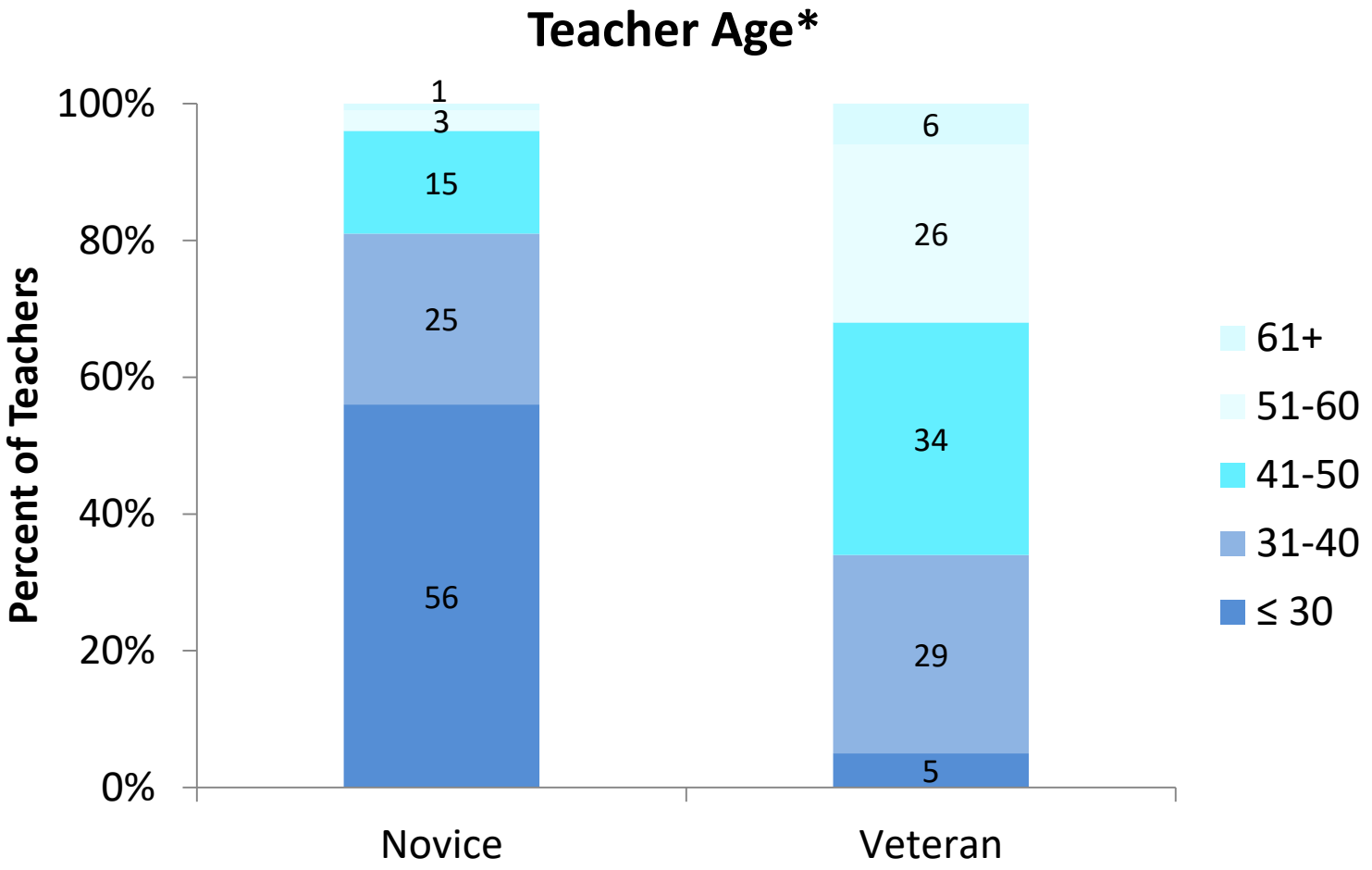
The 2018 NSSME+ collected data on:

- Sex
- Race/ethnicity
- Age
- School Contexts
- Content background (certification and coursework)
- Beliefs
- Preparedness

Characteristics of the Elementary Science Teaching Force

	Percent of Teachers	
	Novice	**Veteran**
Sex		
Female	96	93
Male	4	7
Race/Ethnicity		
White	88	88
Black or African-American	10	8
Hispanic or Latino	10	8
Asian	5	1
American Indian/Alaskan Native	1	2
Native Hawaiian/Other Pacific Islander	0	1

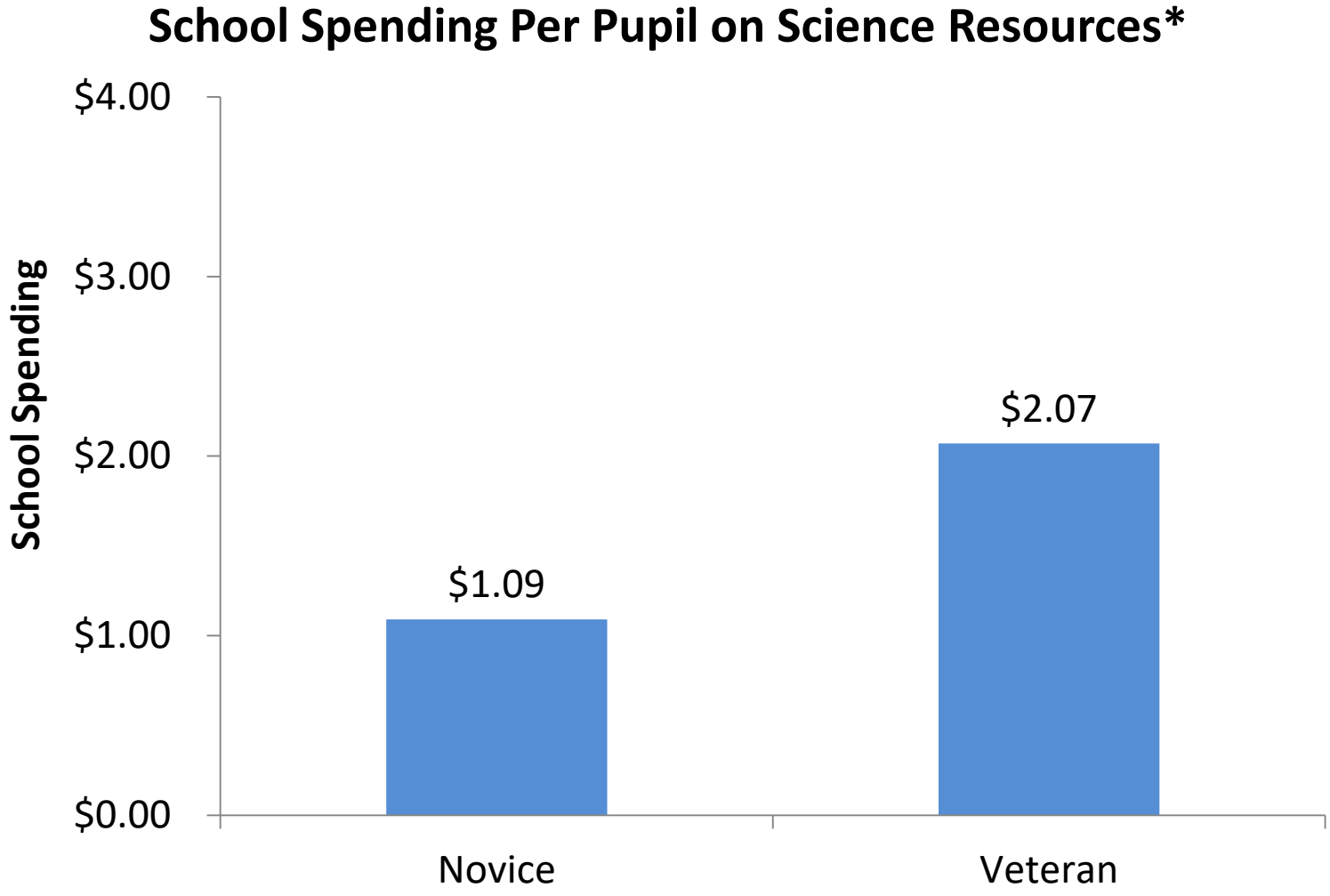
Characteristics of the Elementary Science Teaching Force



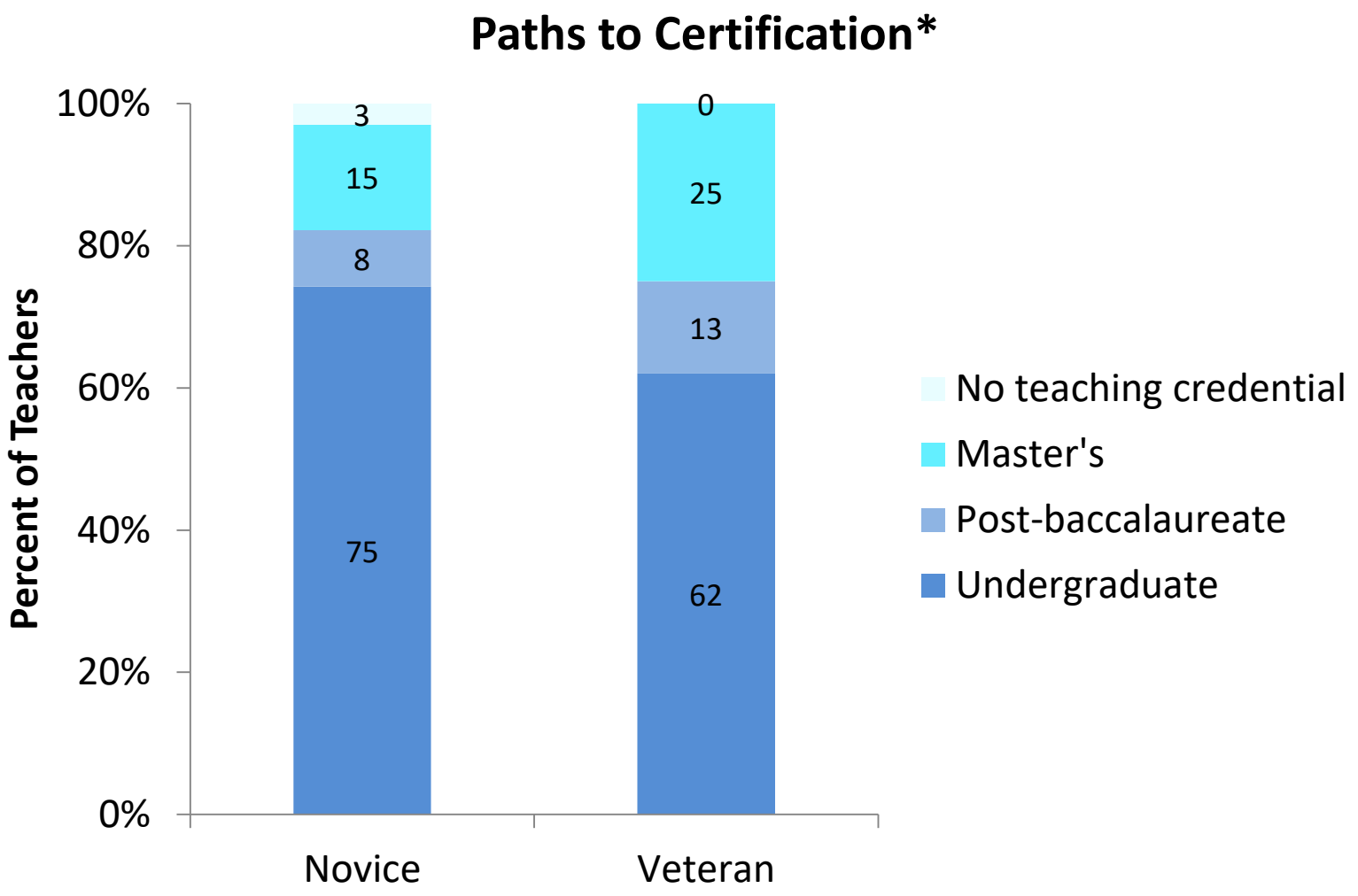
School Contexts

	Percent of Teachers	
	Novice	**Veteran**
School Type		
Catholic	4	3
Non-Catholic Private	5	3
Public	92	94
Community Type		
Rural	20	19
Suburban	49	56
Urban	31	25

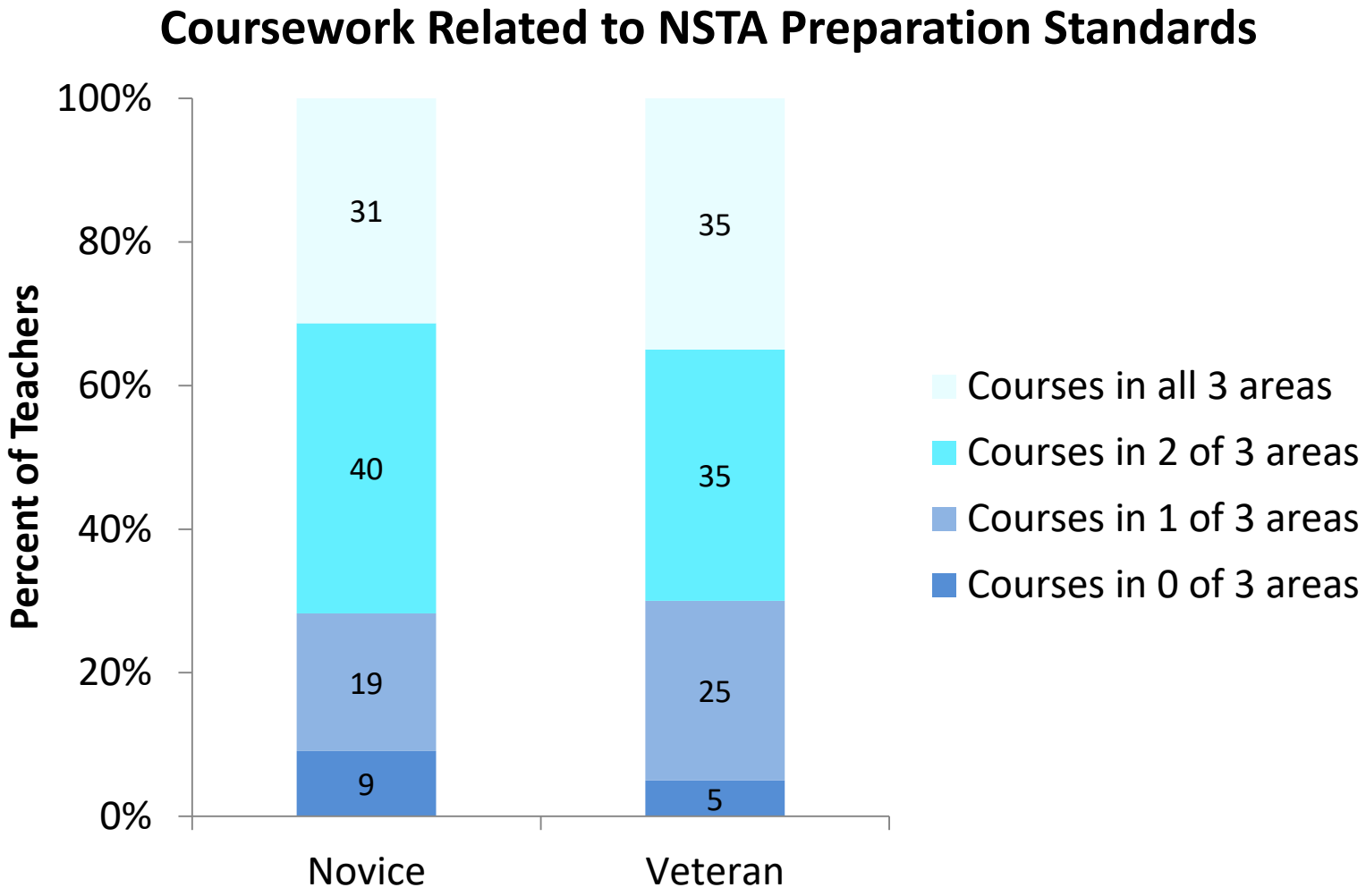
School Contexts



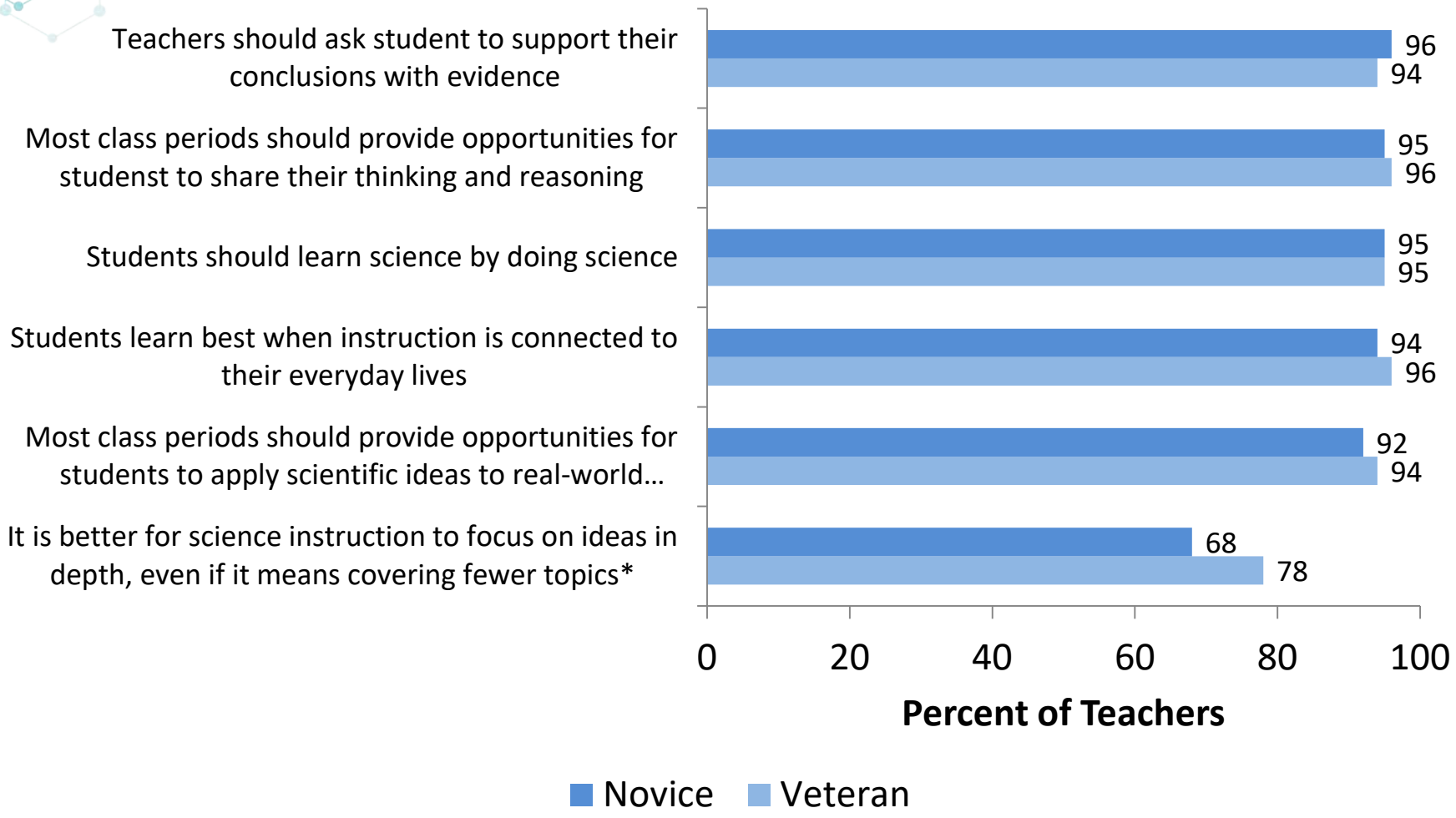
Certification



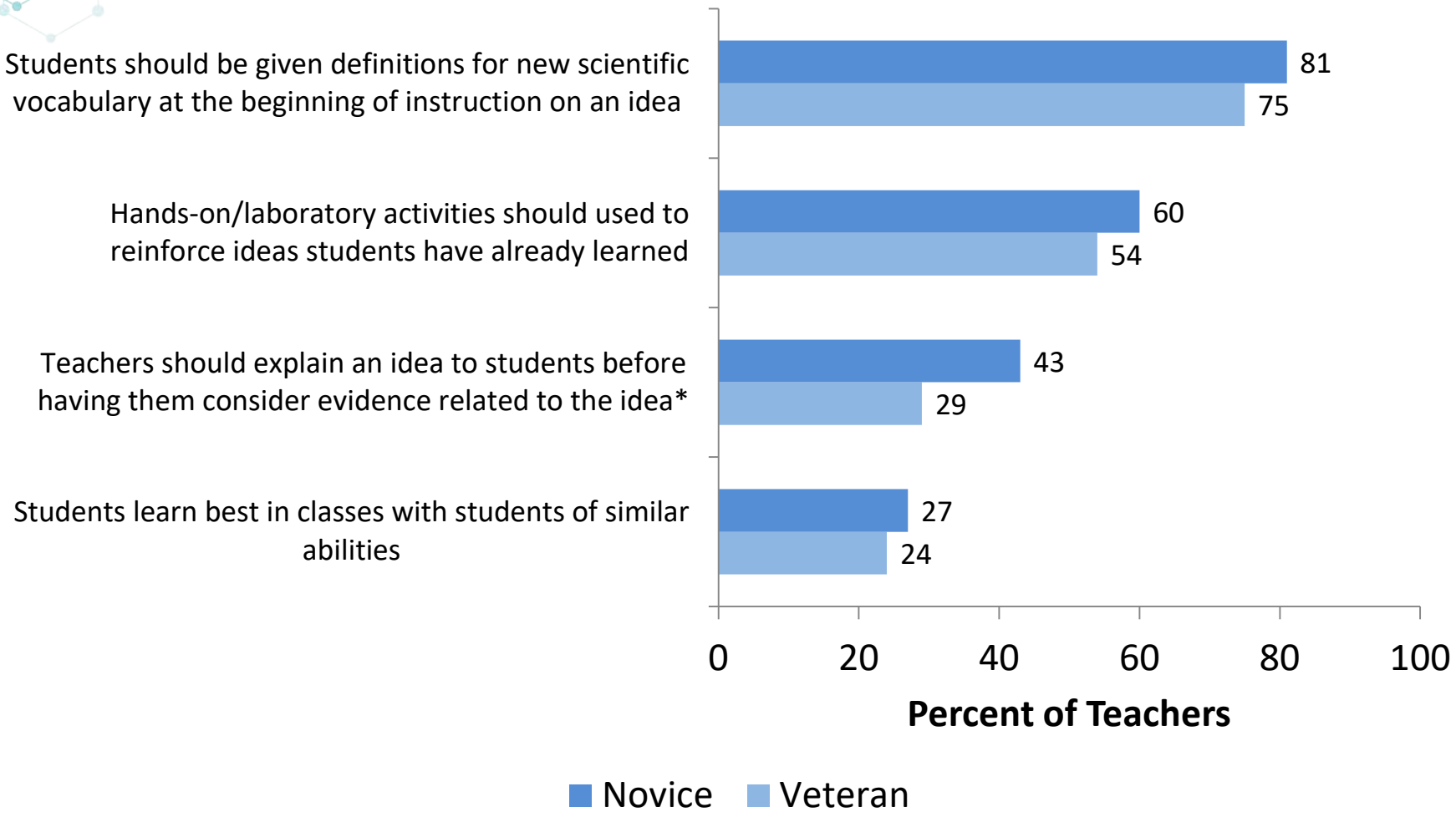
Content Preparation



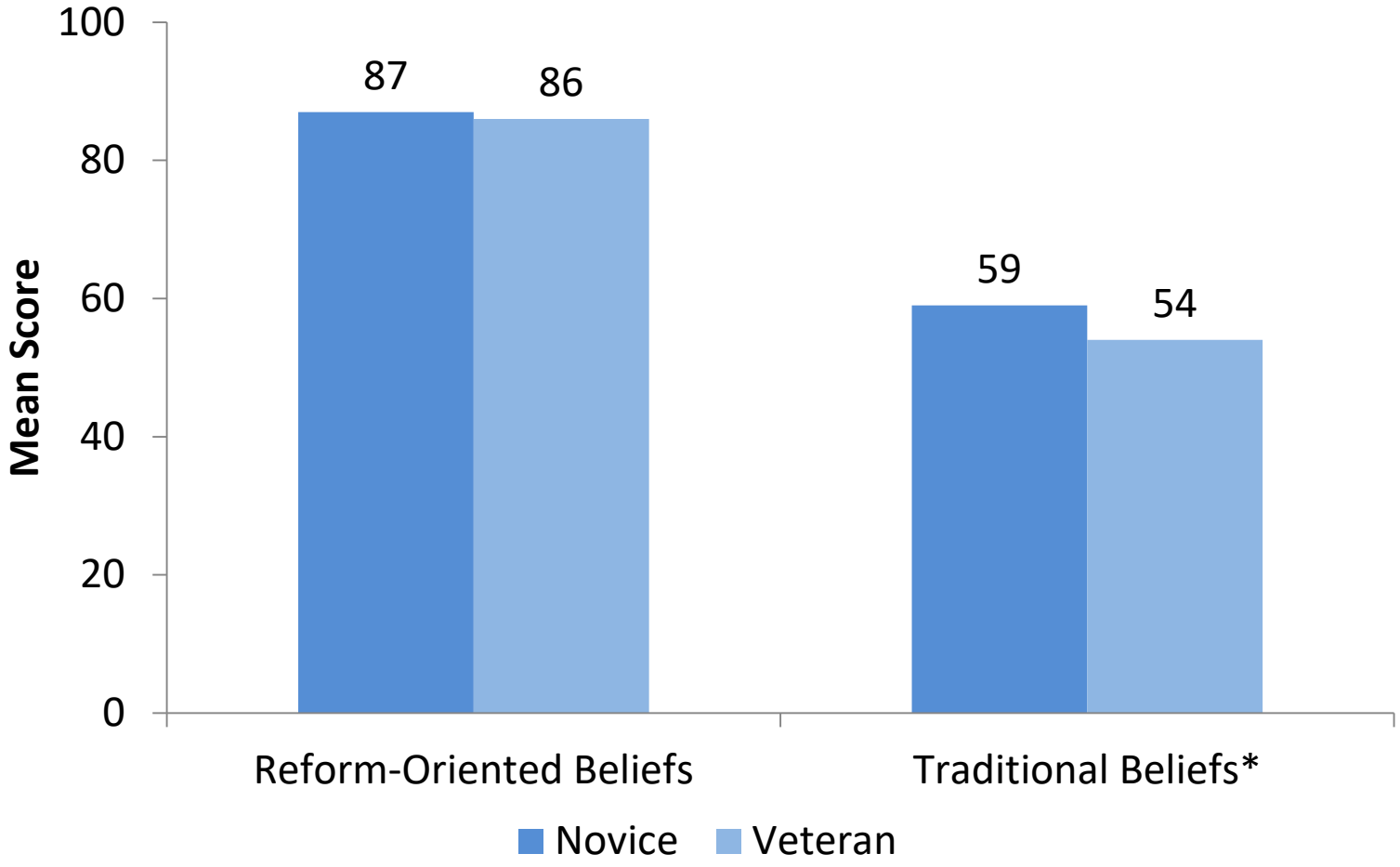
Teachers Agreeing With Various Reform-Oriented Teaching Beliefs



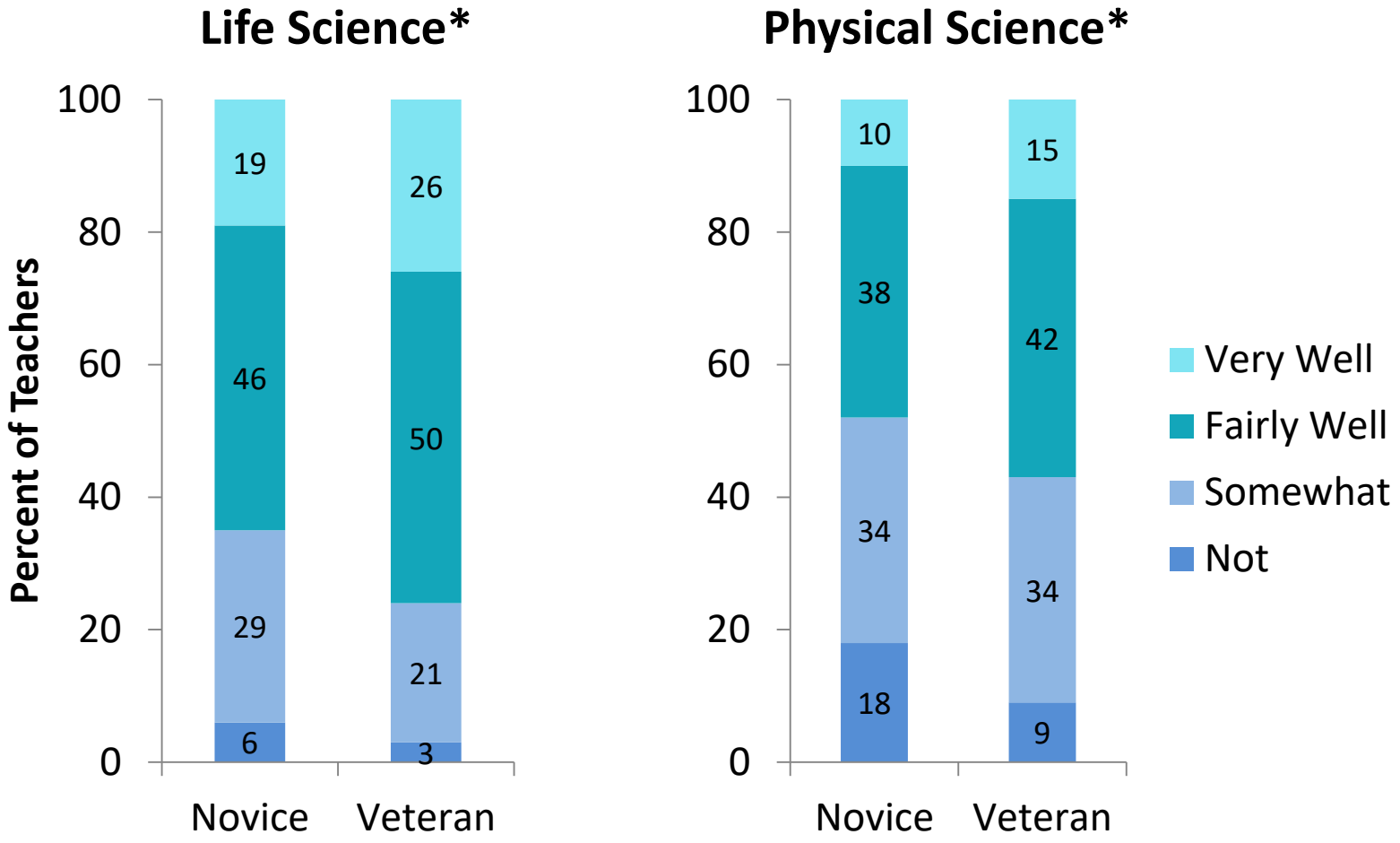
Teachers Agreeing With Various Traditional Teaching Beliefs



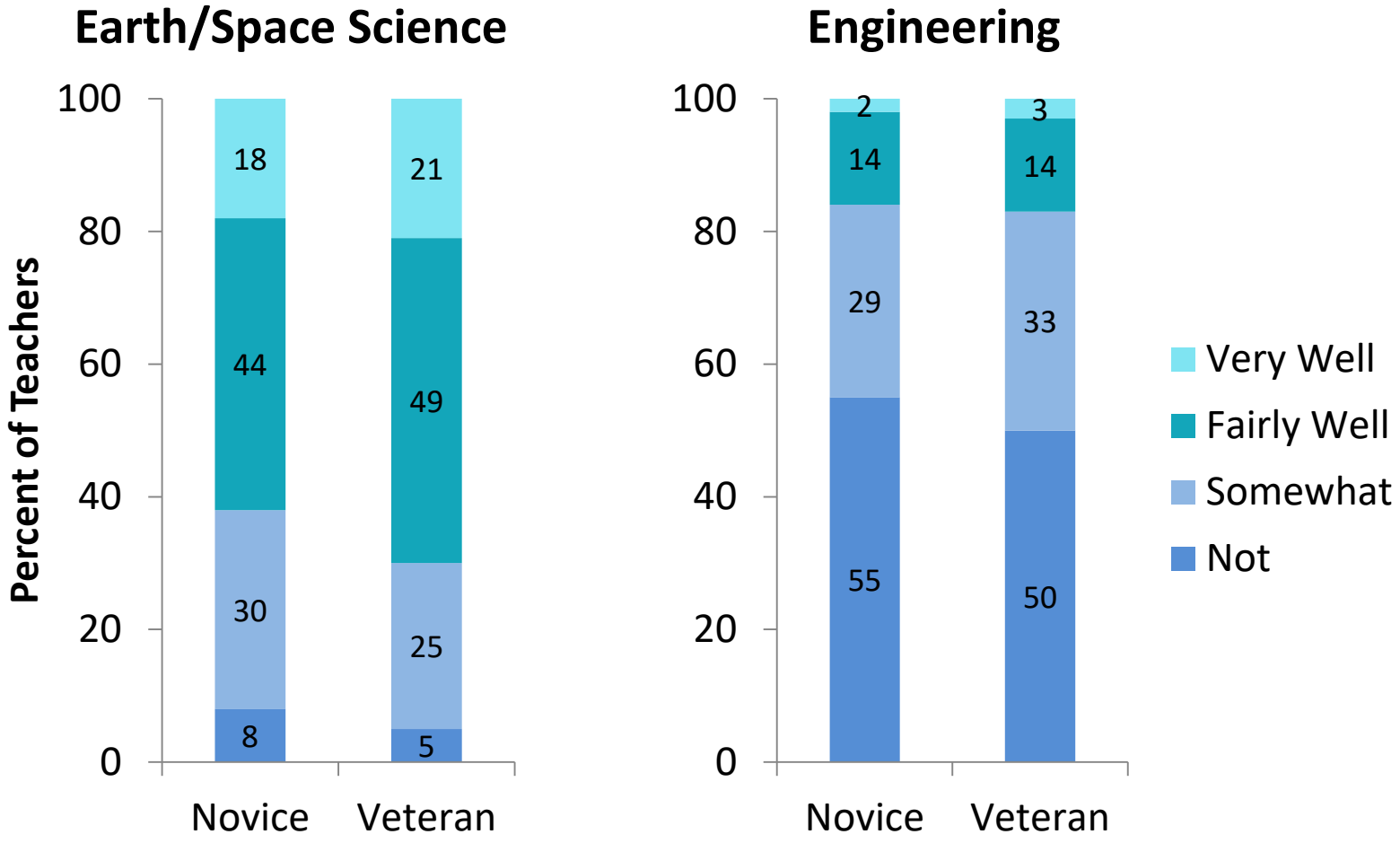
Beliefs About Teaching and Learning



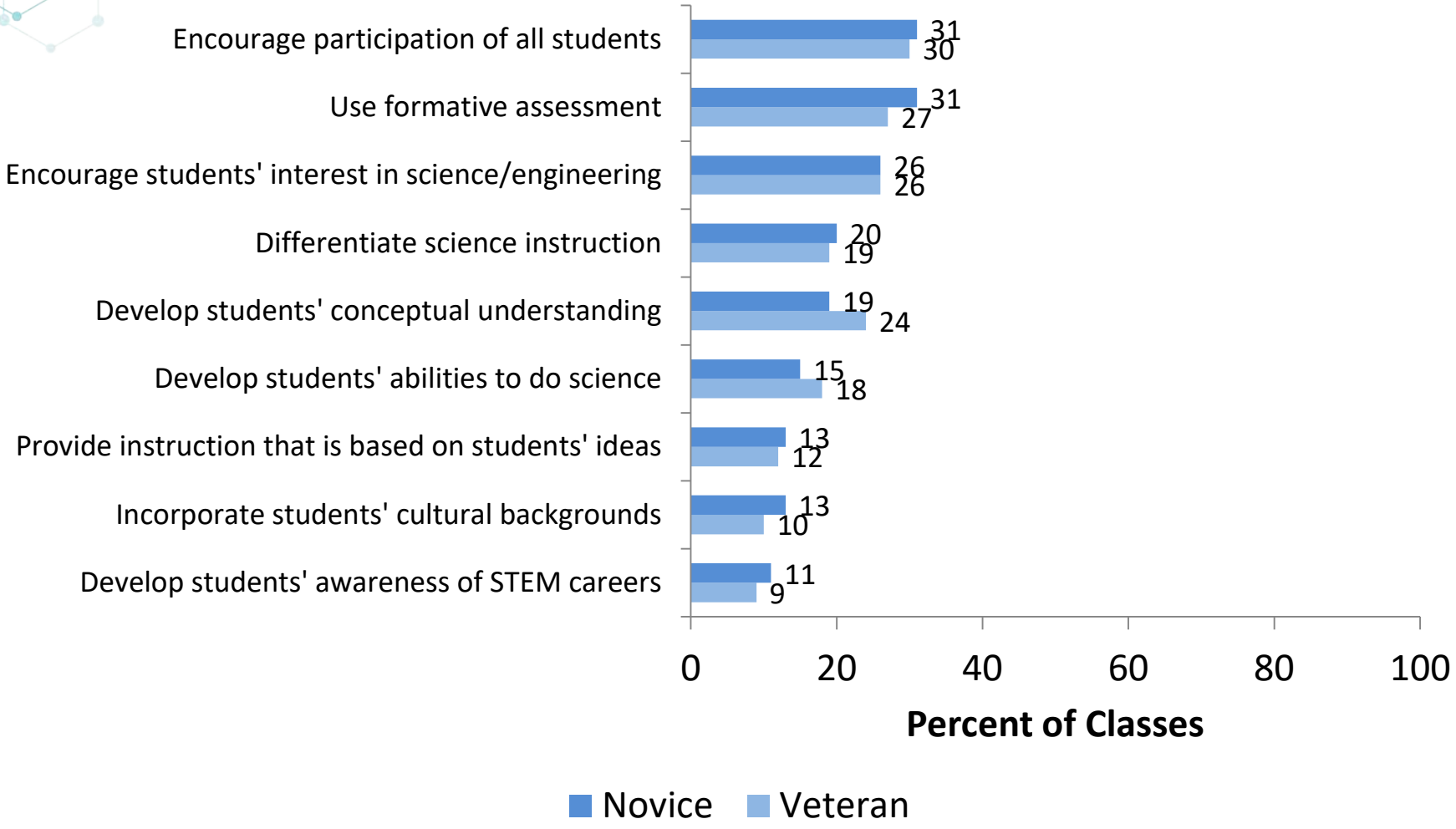
Preparedness to Teach Various Science Disciplines



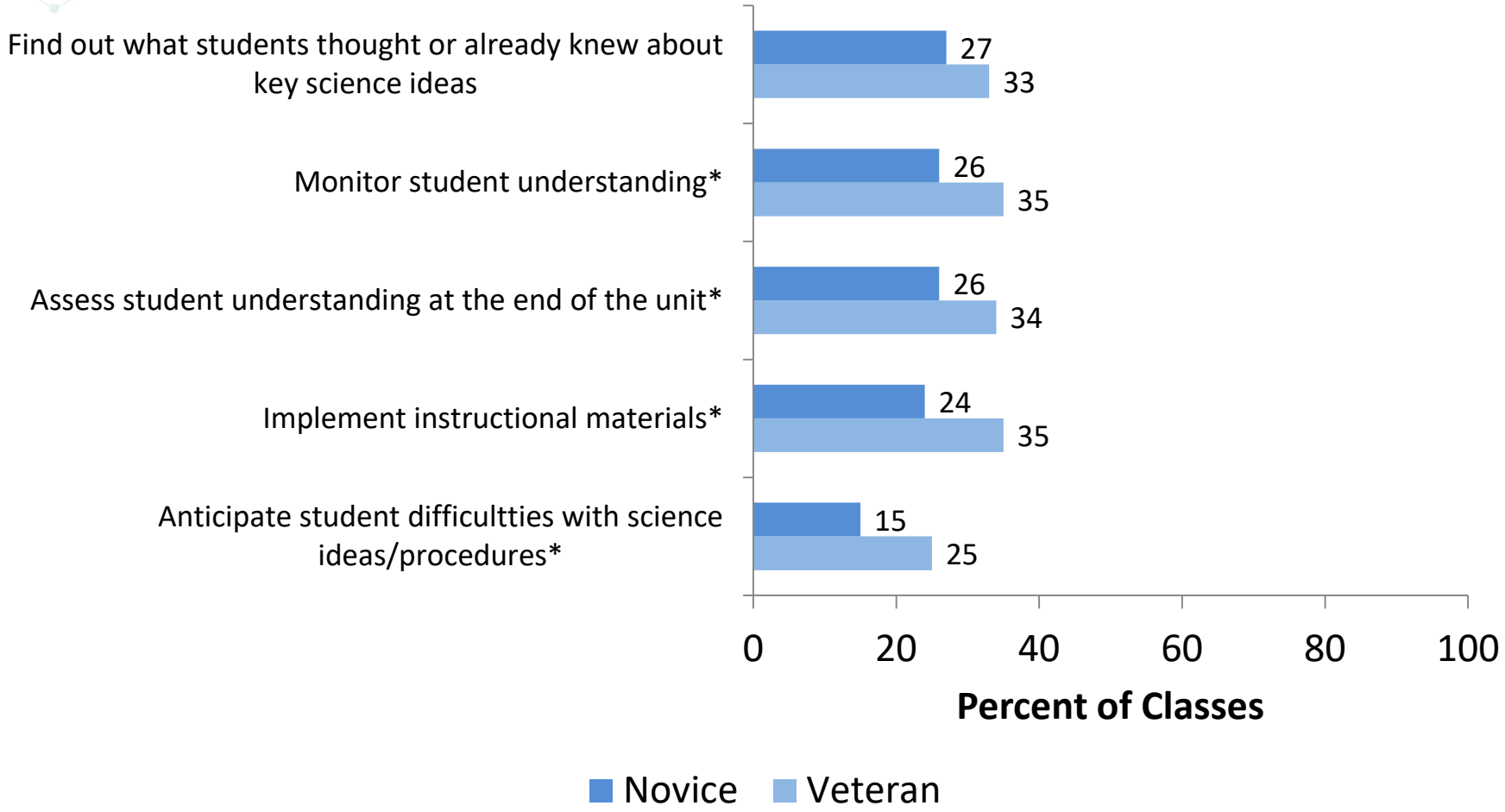
Preparedness to Teach Various Science Disciplines



Very Well Prepared for Instructional Tasks

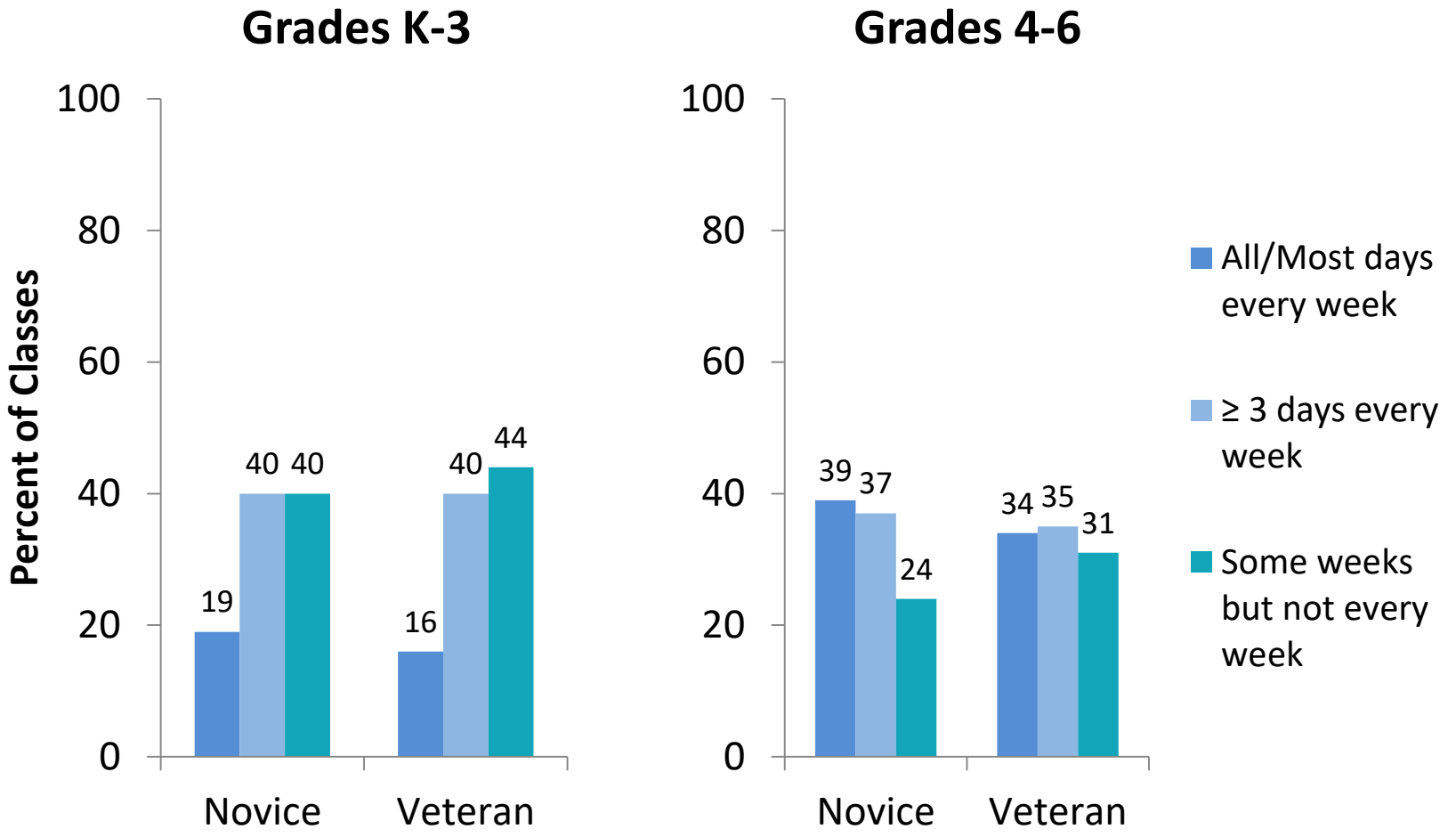


Very Well Prepared to Monitor and Address Student Understanding in Most Recent Unit

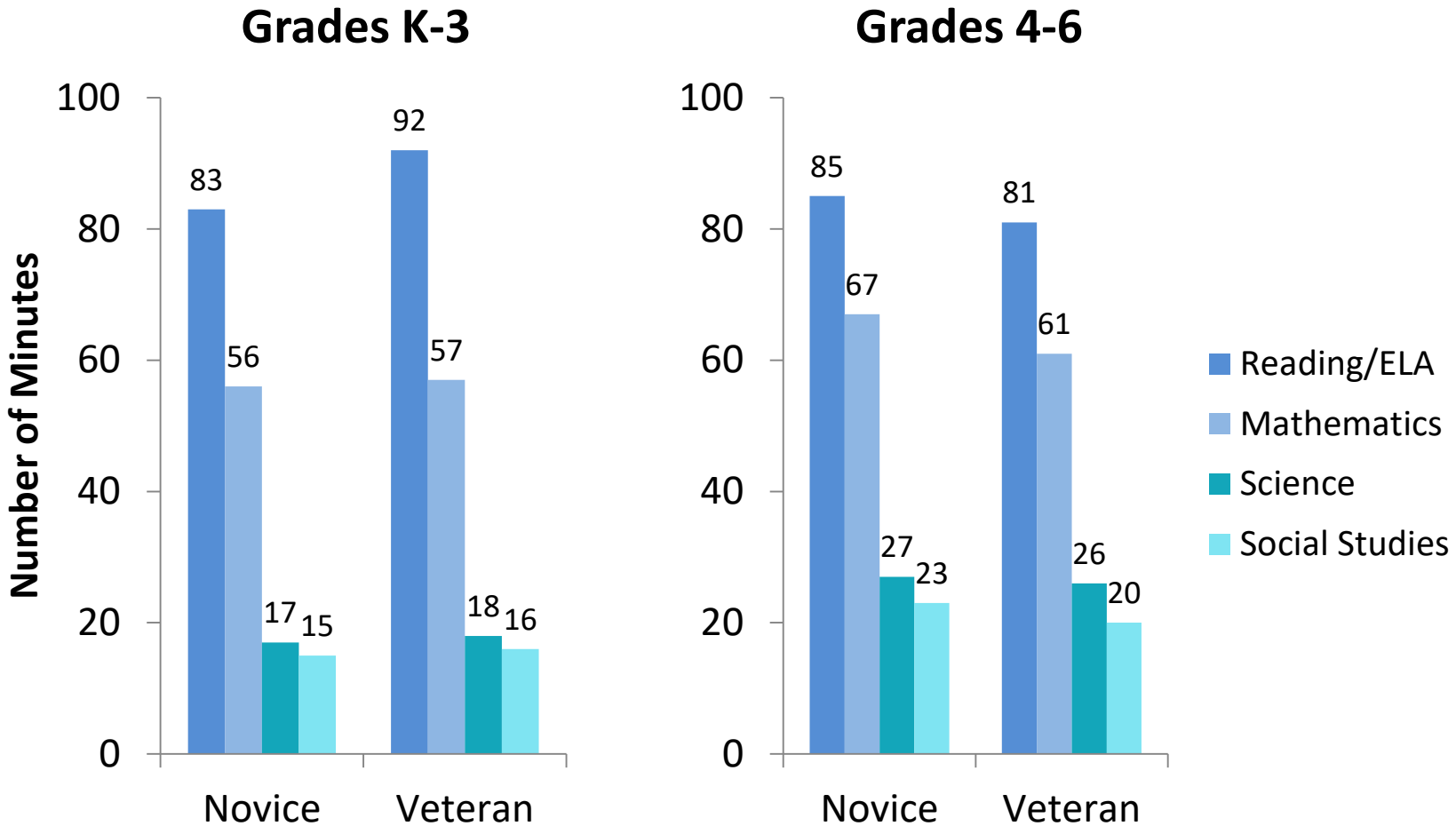


Elementary Science Instruction

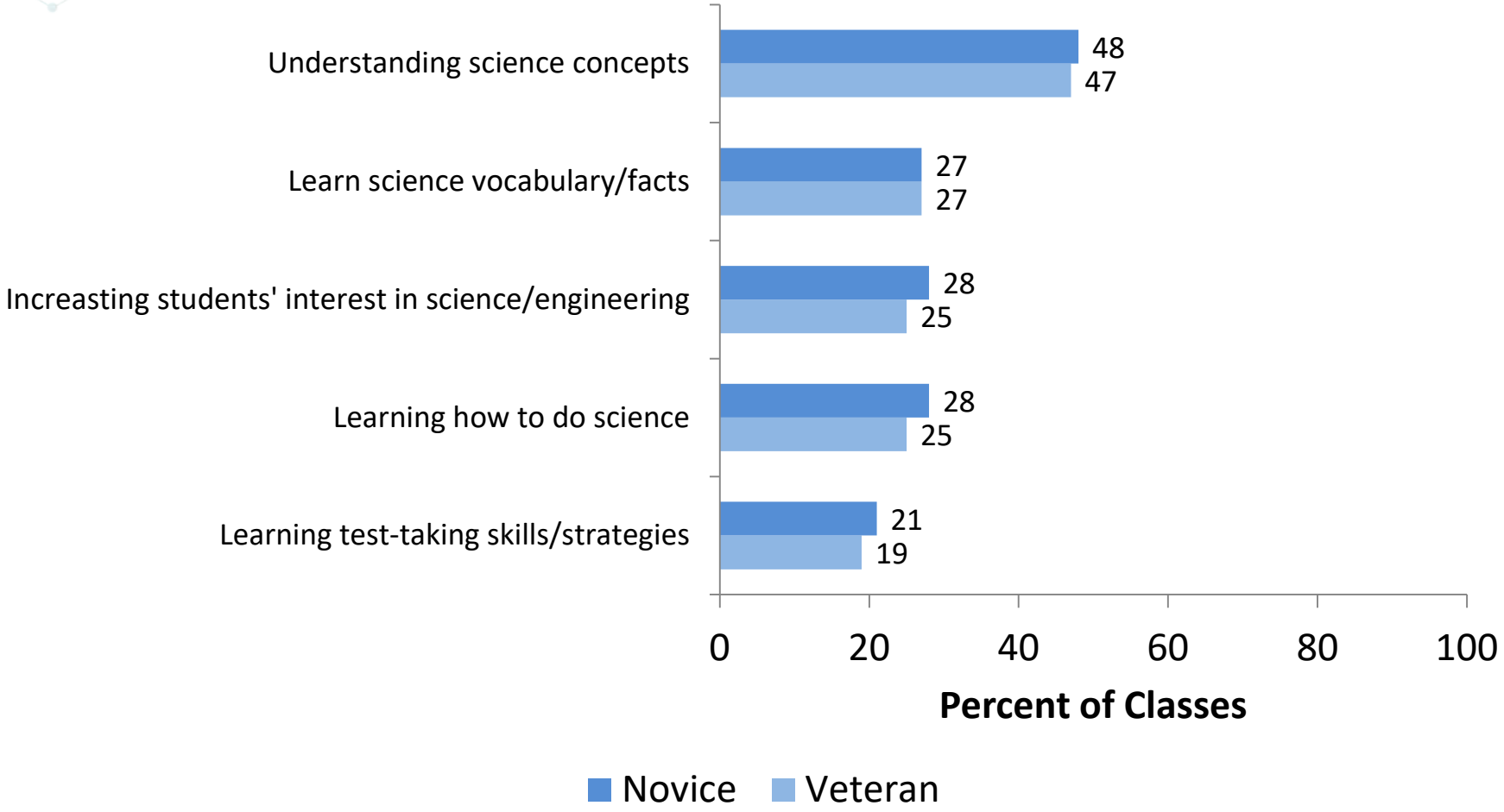
Frequency of Instruction



Minutes Per Day on Instruction



Heavy Emphasis on Instructional Objectives



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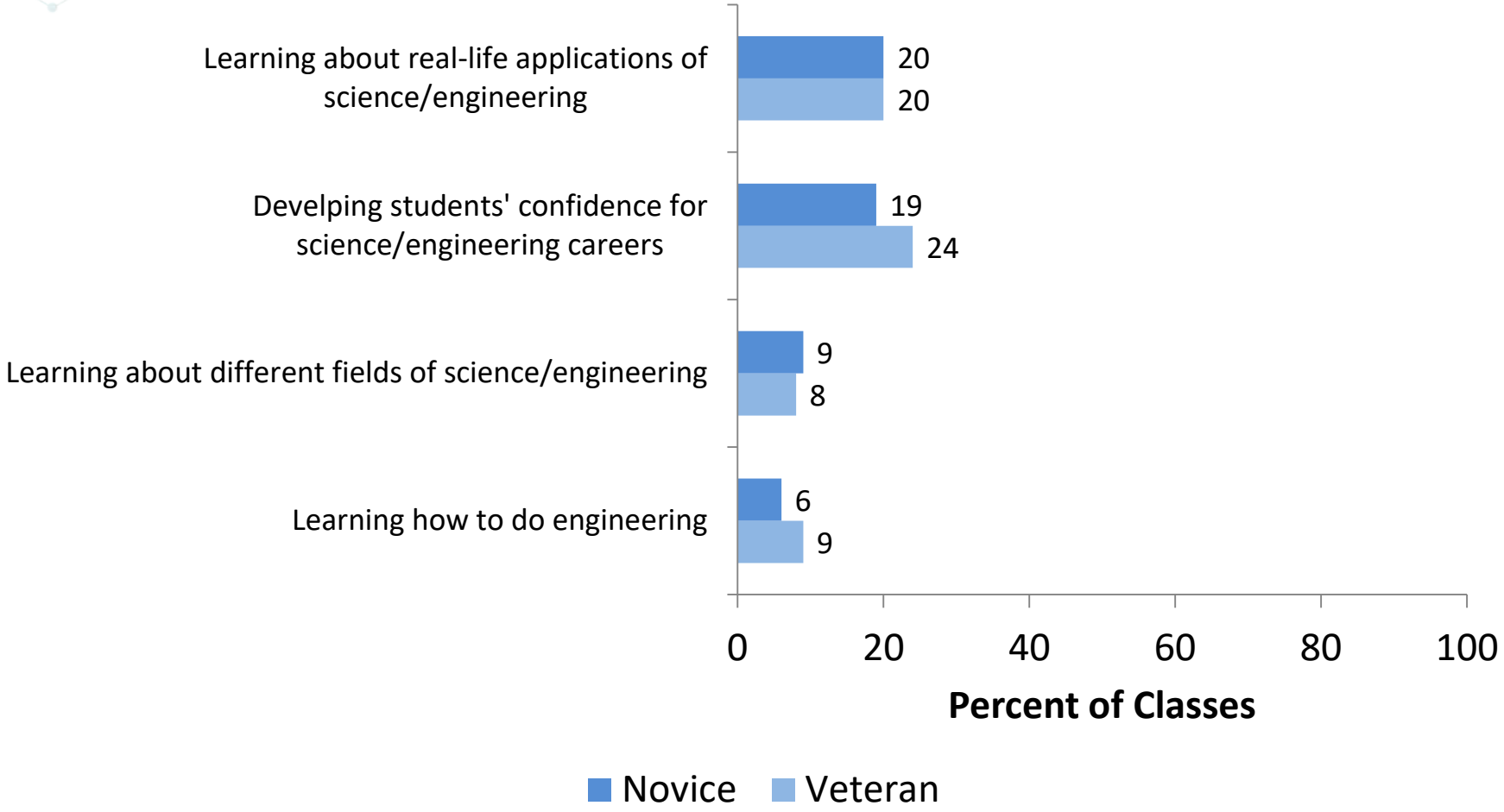
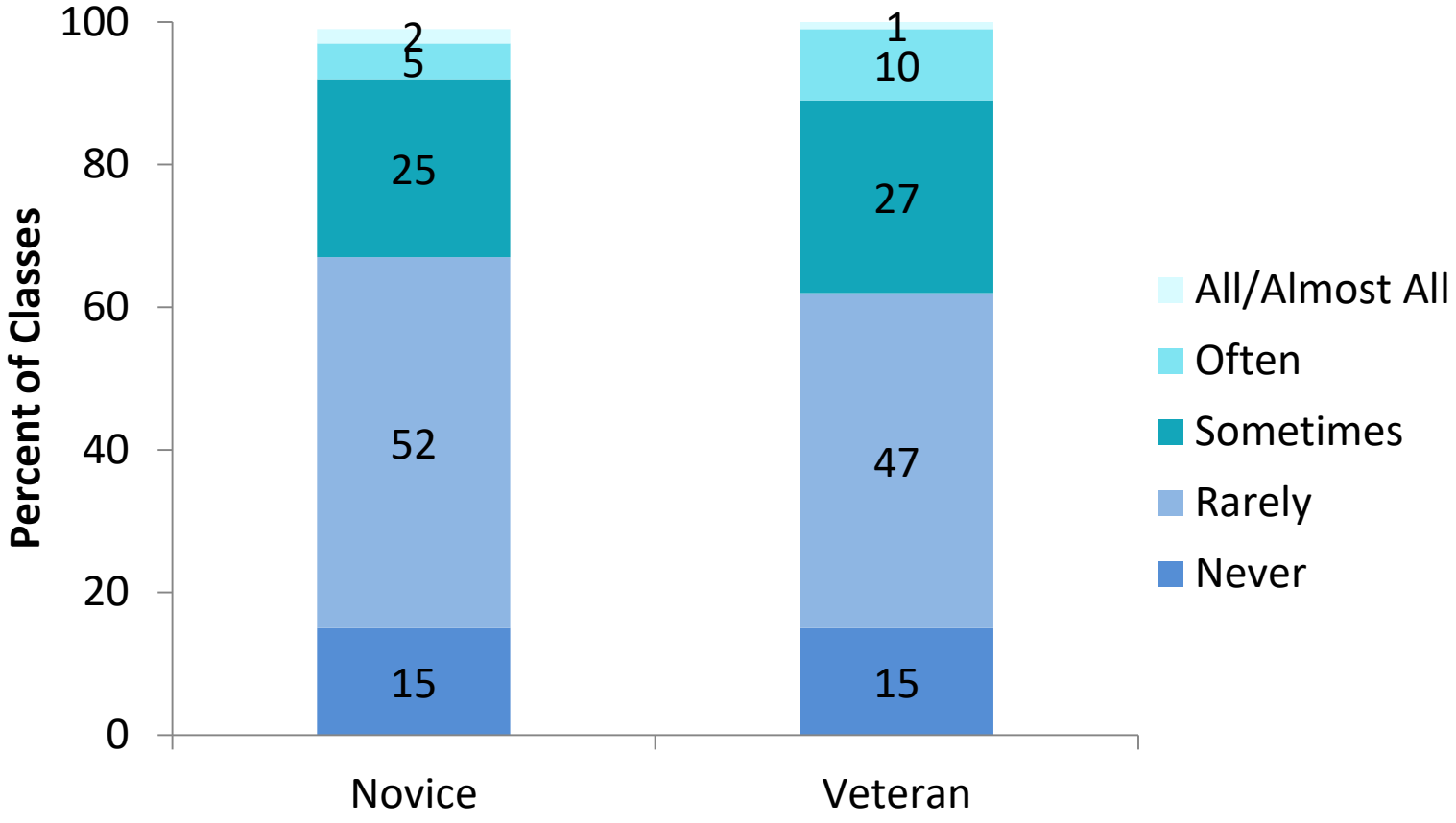
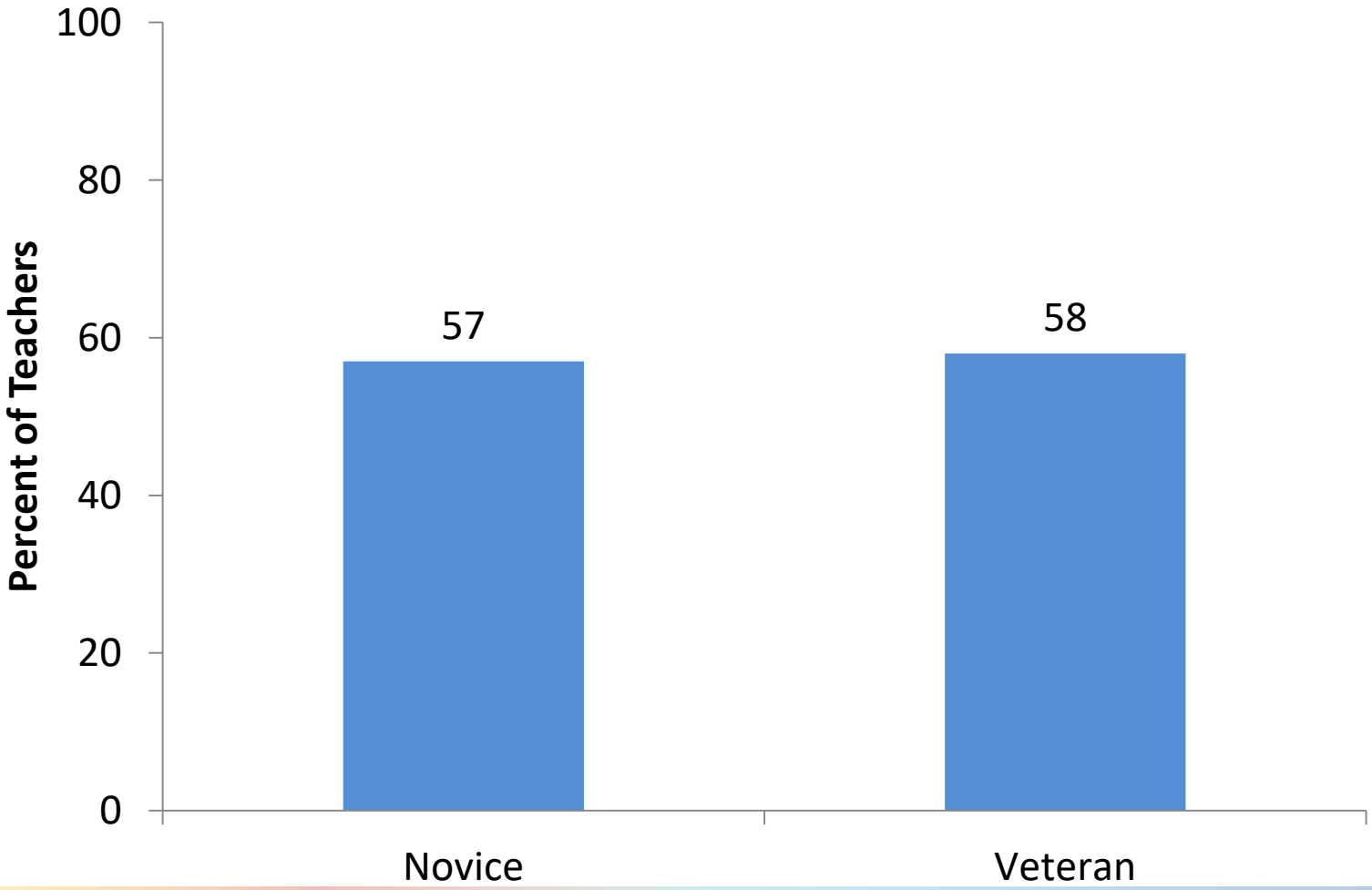


Incorporating Engineering into Science Instruction

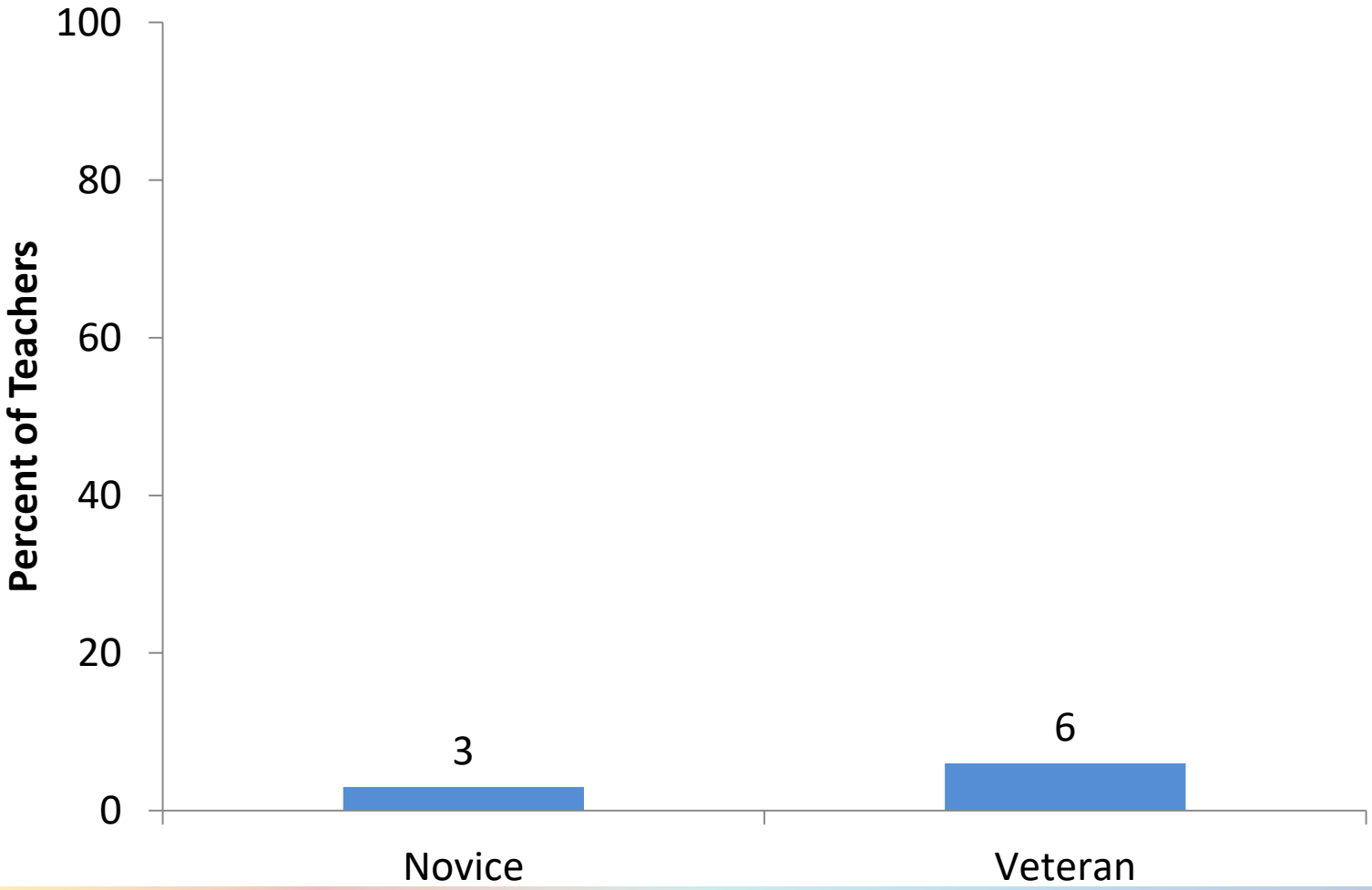


Support for Novice Teachers

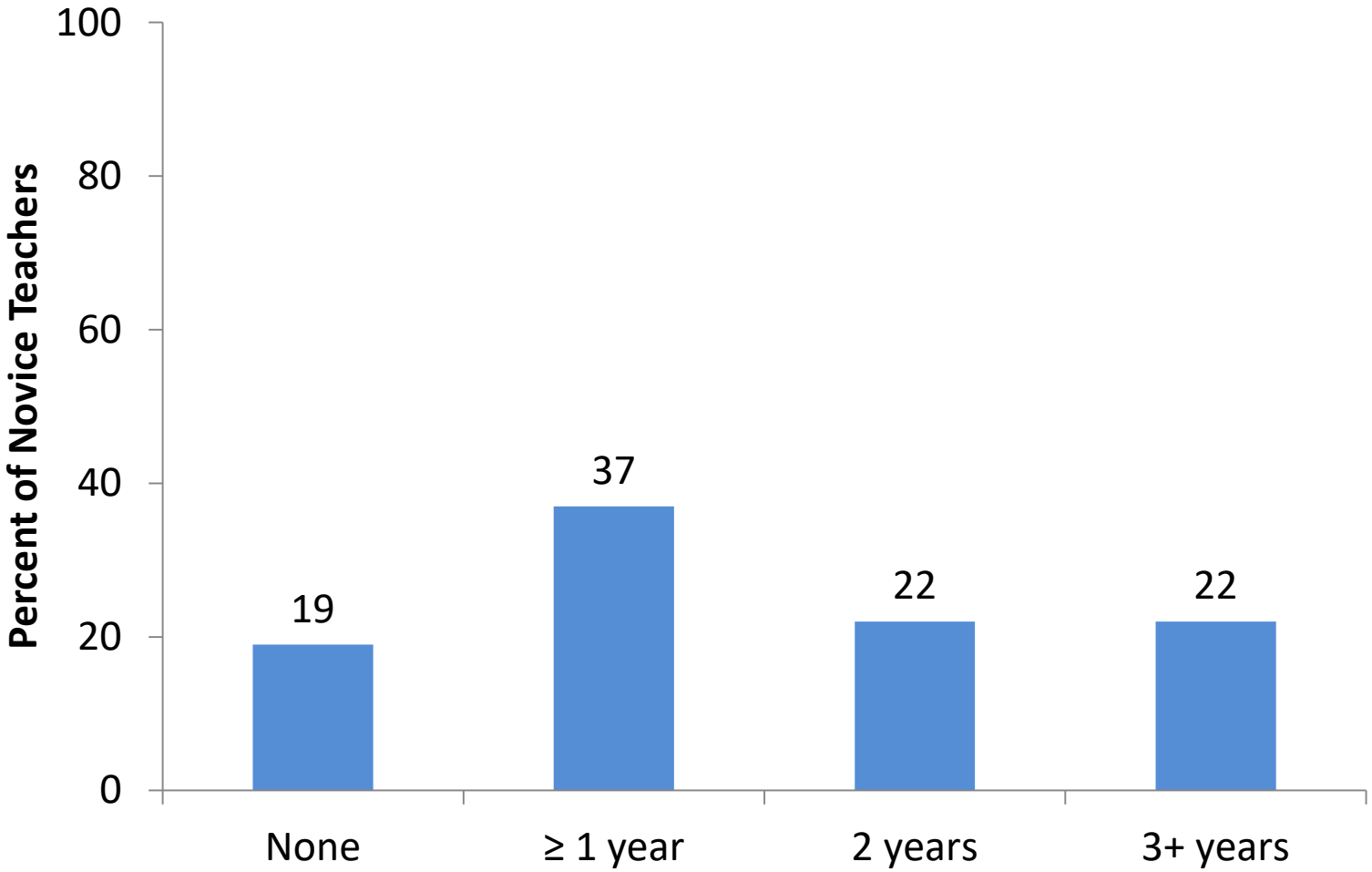
Participation in Science PD in Previous Three Years



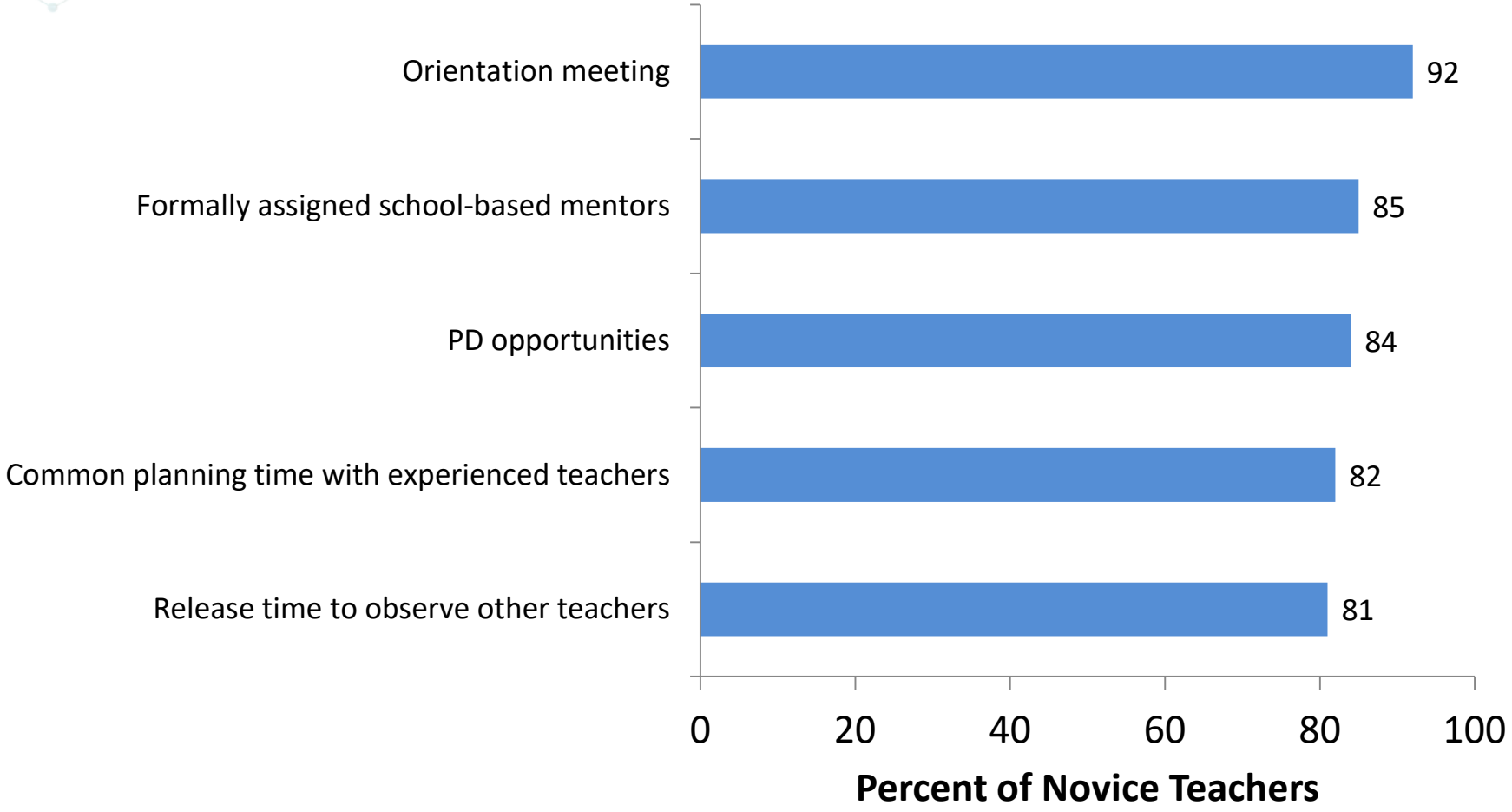
More Than 35 Hours of Science PD in Previous Three Years



Duration of Formal Induction Programs



Supports Provided as Part of Formal Induction Programs



Takeaways

Some key differences between novices and veterans:

- Content preparedness
- Pedagogical preparedness
- Instructional beliefs

Many commonalities which suggest room for professional growth

- PD data suggest elementary teachers are not getting the support they need to “mature” as professionals throughout their teaching careers

Takeaways

Given the large percentage of novice elementary teachers that participate in induction programs, perhaps it is possible to leverage induction program supports:

- School-based mentors might devote time to helping novices increase their science content knowledge or diversify their science teaching practices
- School leaders may strategically choose teachers for novices to observe when they are given release time to do so

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Factors That Predict the Extent to Which Elementary Teachers' Engage Students in the Science Practices

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Analytic Approach

The 2018 NSSME+ collected data about the nature of instruction in elementary science classes

Study also collected tons of data about teachers, schools, and instructional resources

This analysis looked at school, class, and teacher characteristics that are associated with instructional practices

Outcomes

Composite variables measuring:

1. Reform-oriented instructional objectives
2. Extent instruction engages students with the practices of science

Reform-Oriented Instructional Objectives

How much emphasis each would receive over the entire course:

1. Understanding science concepts
2. Learning about different fields of science/engineering
3. Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)
4. Learning how to do engineering (e.g., identify criteria and constraint, design solutions, optimize solutions)
5. Learning about real-life applications of science/engineering
6. Increasing students' interest in science/engineering
7. Developing students' confidence that they can successfully pursue careers in science/engineering

Engagement in Science Practices

How often students are engaged in aspects of the science practices:

1. Asking questions/defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations/designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Independent Variables

Schools

- School size
- Community type
- Public vs. private school
- Spending per pupil
- Extent factors are problematic

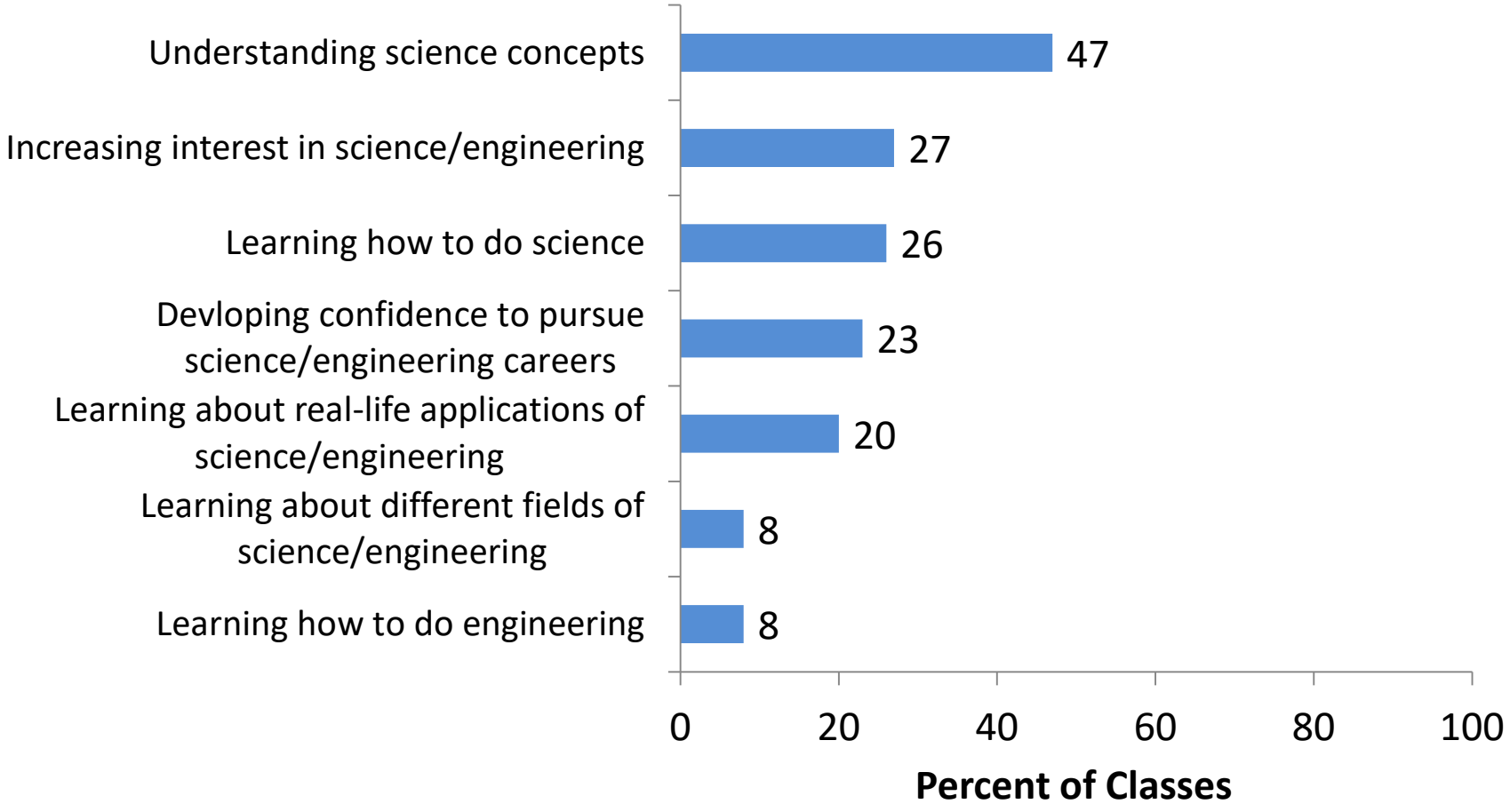
Teachers

- Self-contained
- Years of K-12 science teaching experience
- Minutes of instruction
- Perceptions of preparedness
- Teaching beliefs
- Science-related job before teaching
- Amount of science PD
- Race/sex

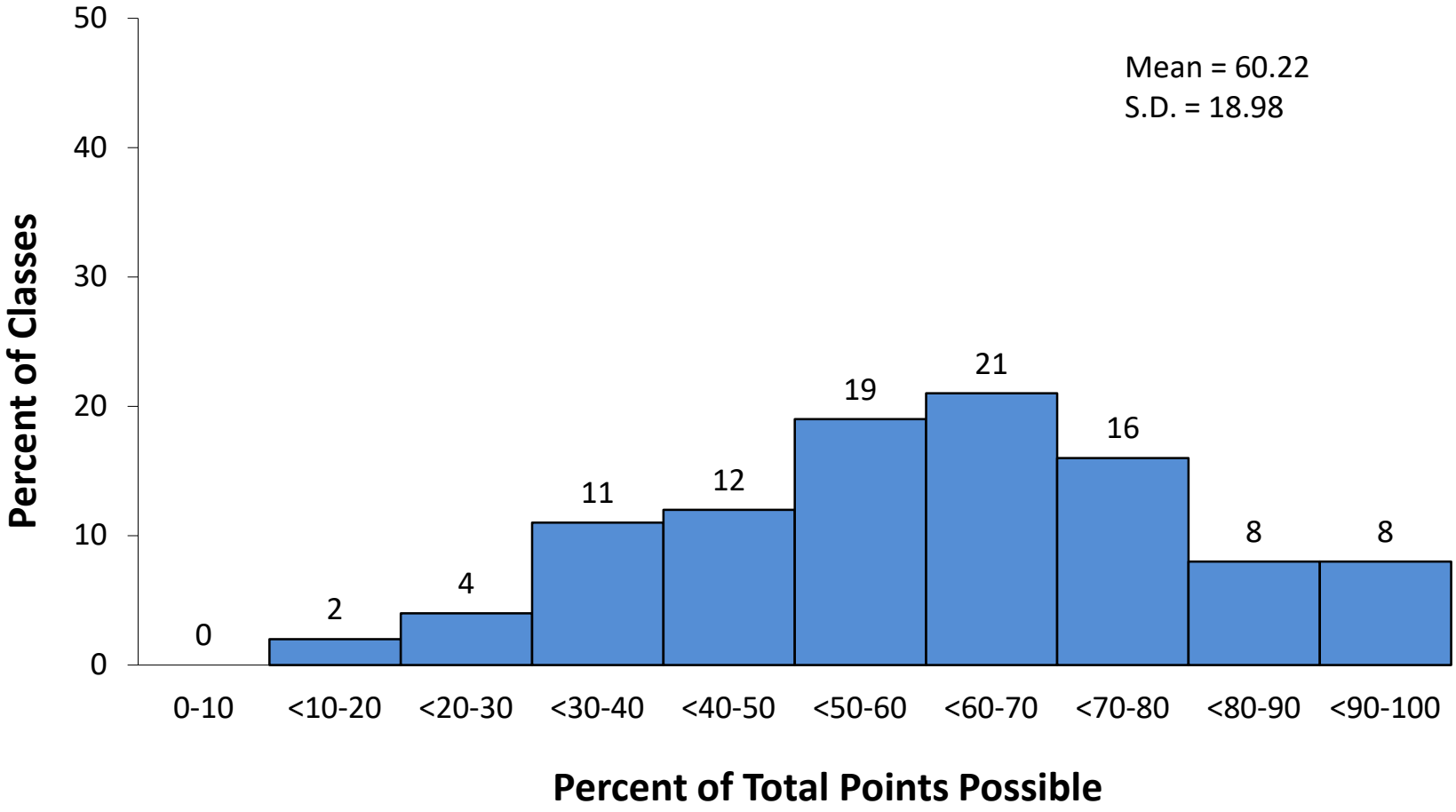
Classes

- Prior achievement level of students
- Class size
- Percent of students in class from race/ethnicity groups historically underrepresented in STEM
- Curriculum control
- Pedagogy control
- Number of instructional materials used often
- Adequacy of resources
- Extent effective instruction is promoted

Reform-Oriented Objectives Receiving a Heavy Emphasis



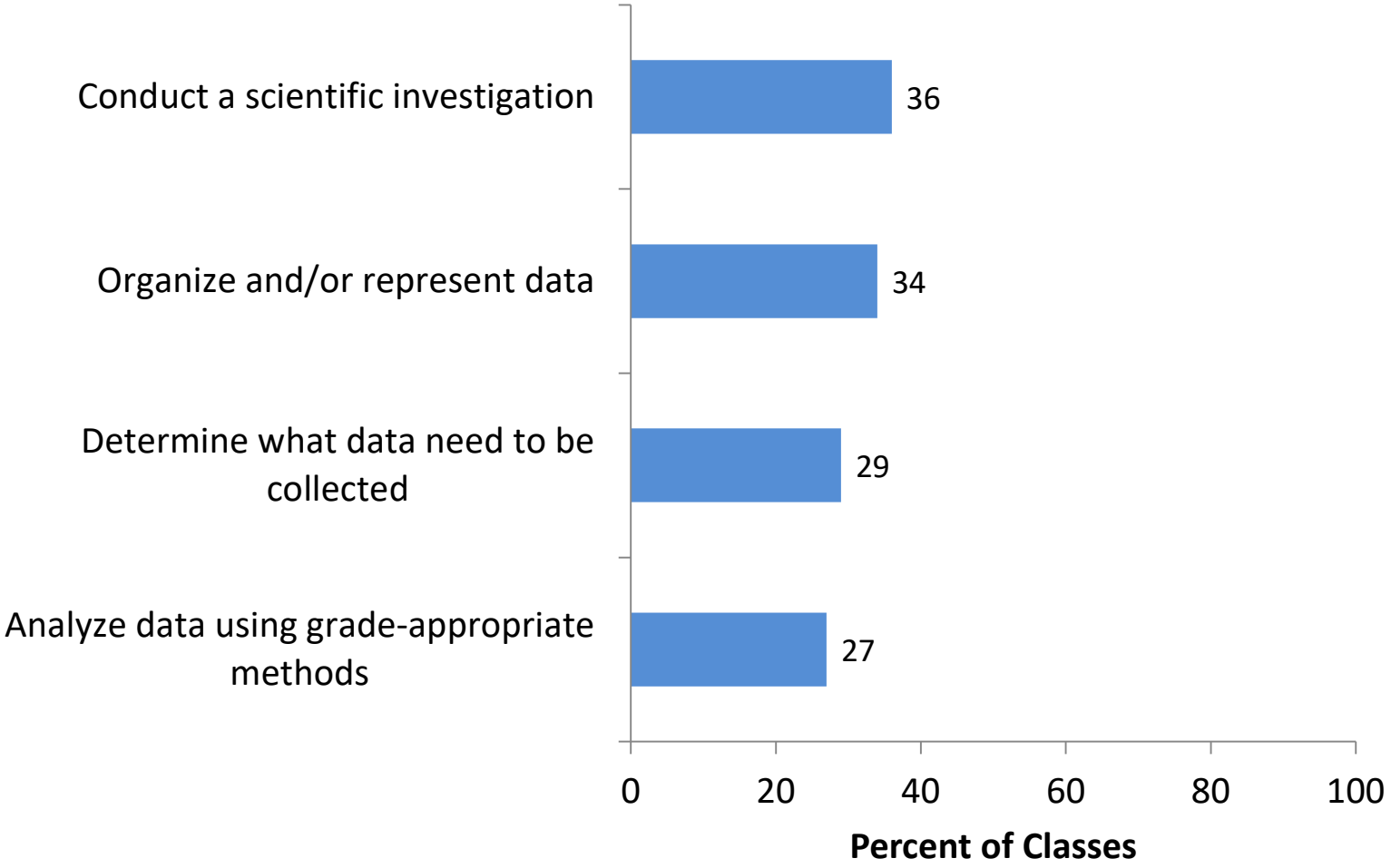
Reform-Oriented Instructional Objectives Composite



Engagement in Science Practices

Students are often engaged in aspects of science related to conducting investigations and analyzing data

Conducting Investigations and Analyzing Data: Weekly

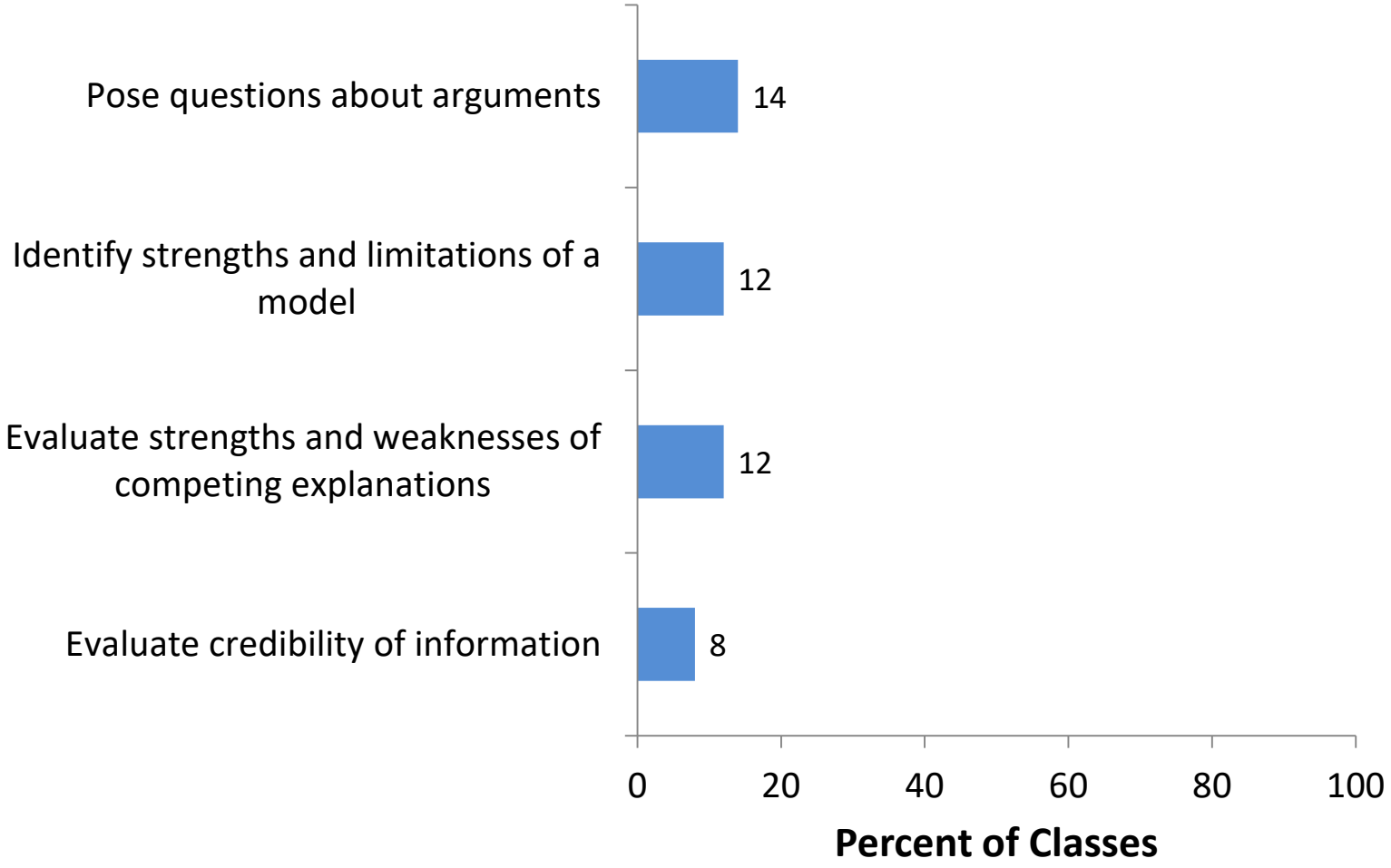


Engagement in Science Practices

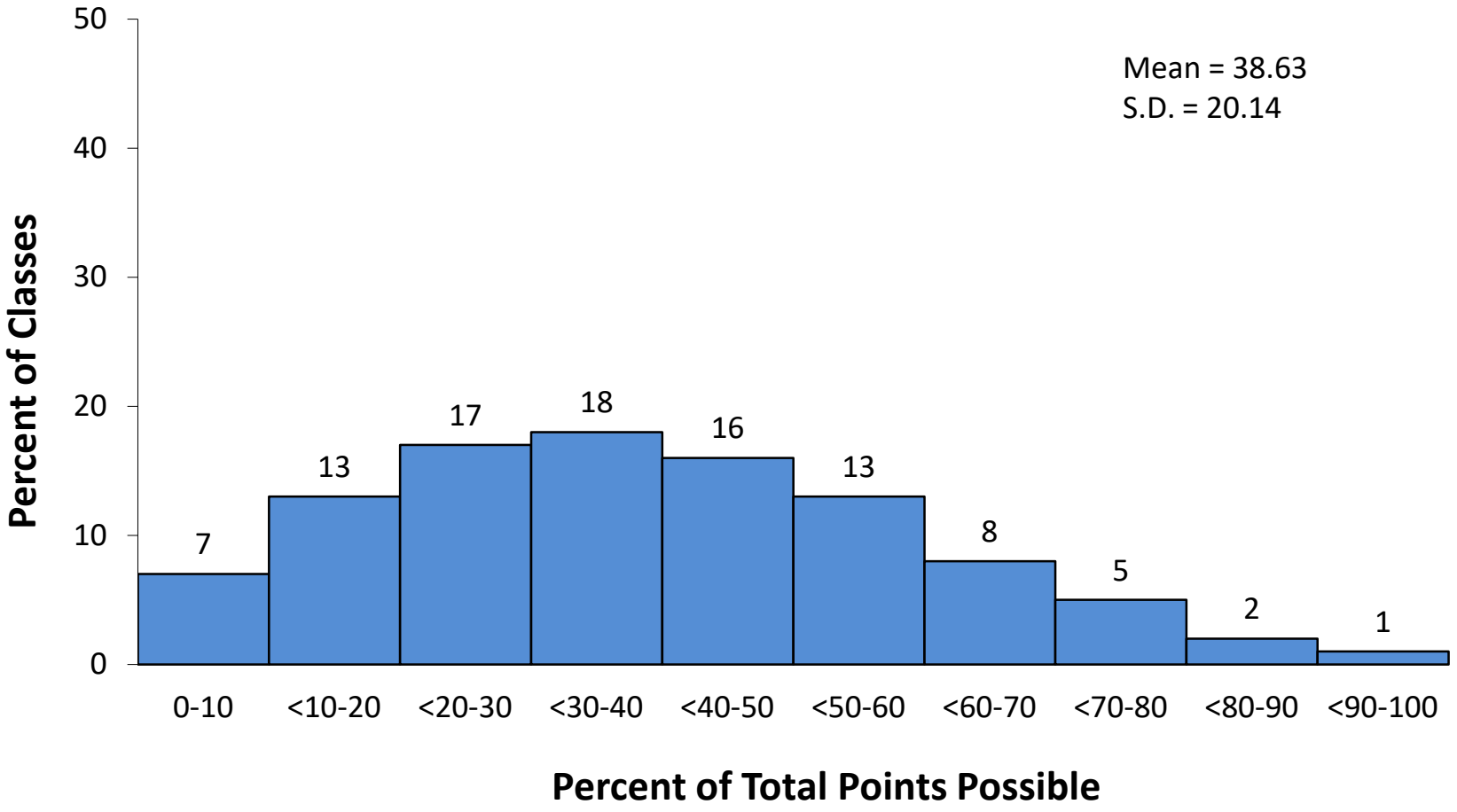
Students are often engaged in aspects of science related to conducting investigations and analyzing data

Students tend to not be engaged very often in aspects of science related to evaluating the strengths/limitations of evidence and the practice of argumentation

Evaluating Evidence and Arguing: Weekly



Engaging Students in the Practices Science Composite



School Independent Variables

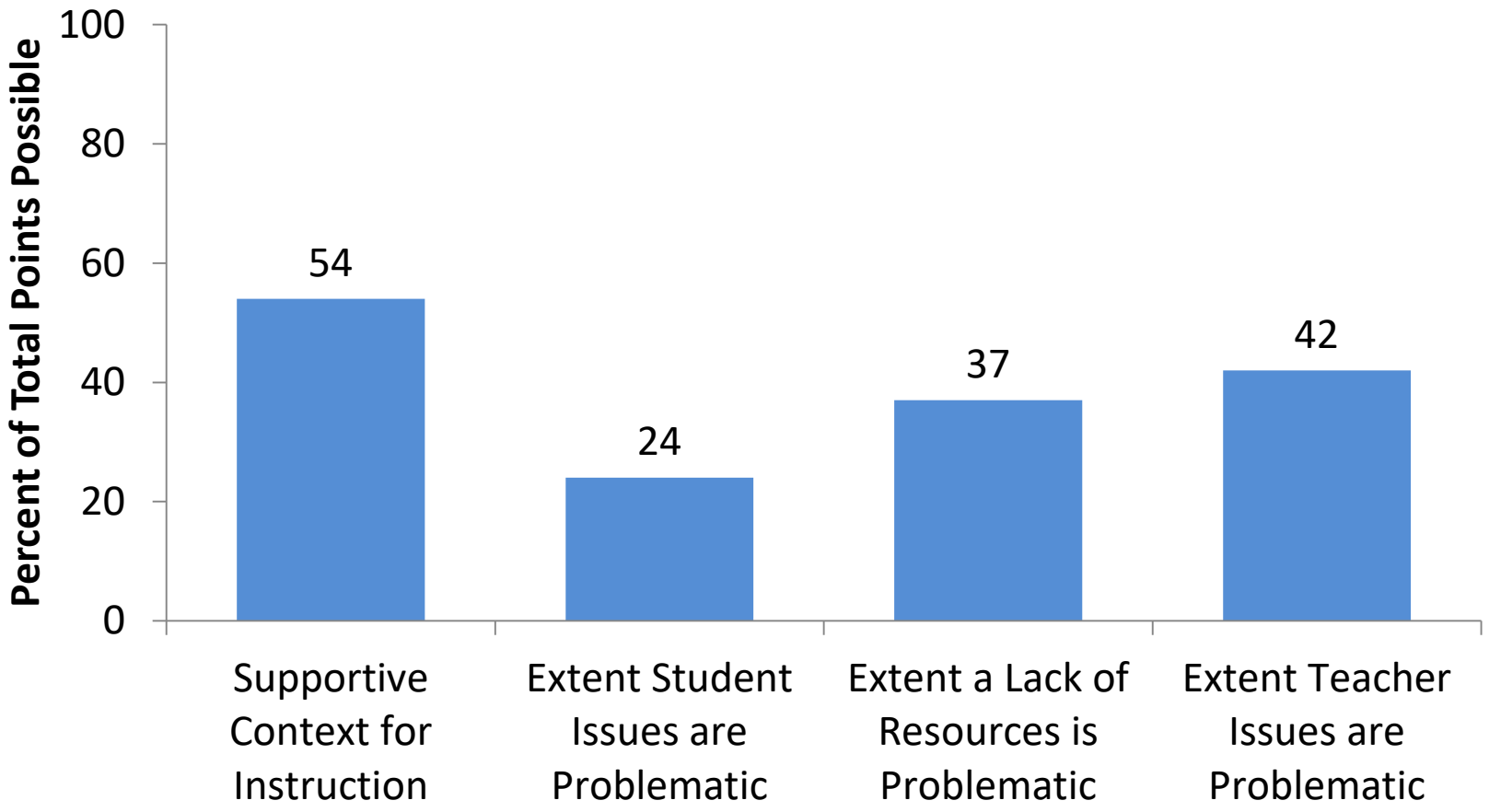
School Independent Variables

	Elementary Schools
Average Number of Students	421
Average Spending Per Pupil	$6.43

School Independent Variables

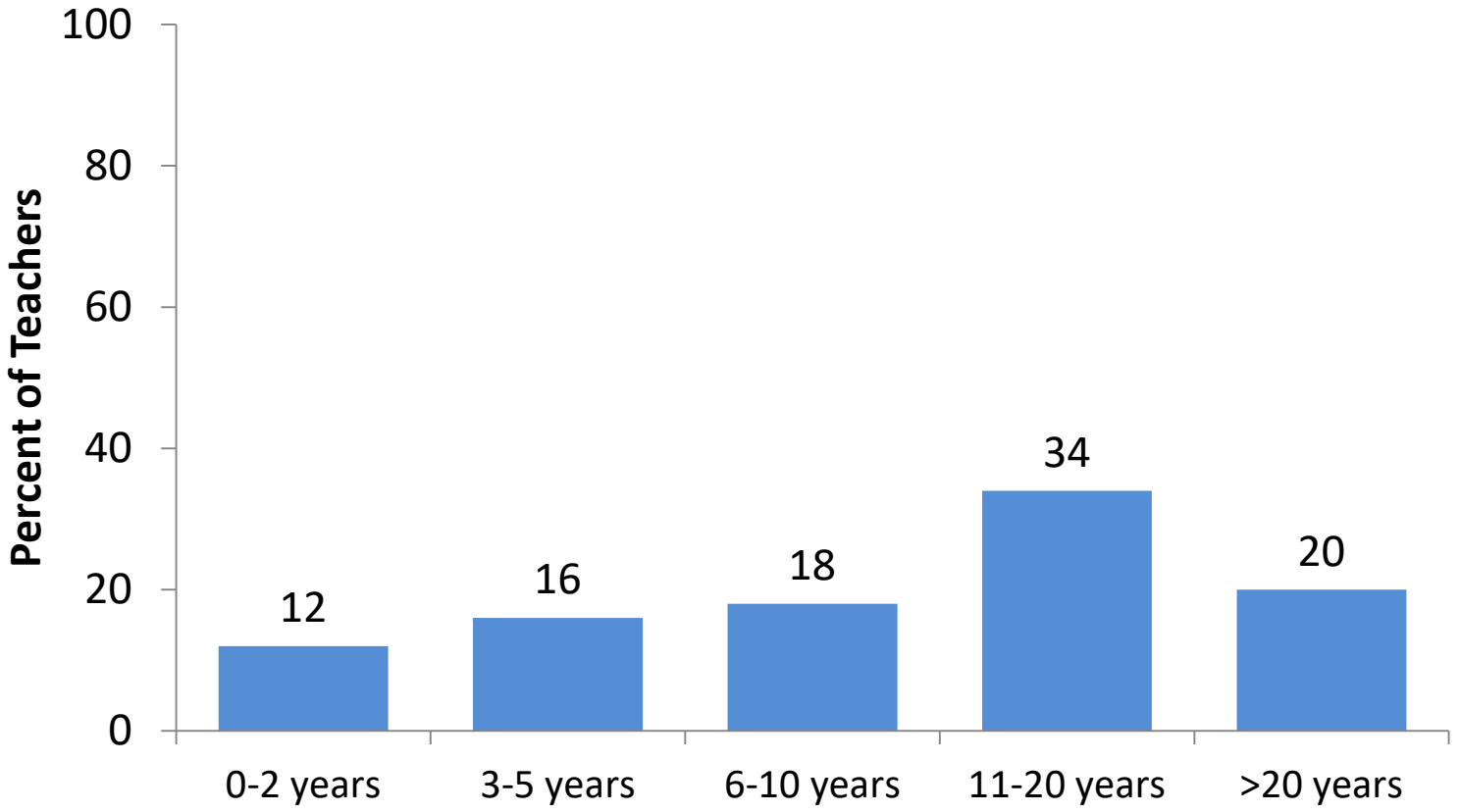
	Percent of Elementary Schools
Community Type	
Rural	24
Suburban	47
Urban	29
School Type	
Public	83
Private	17

School Mean Scores for Factors Affecting Instruction Composites

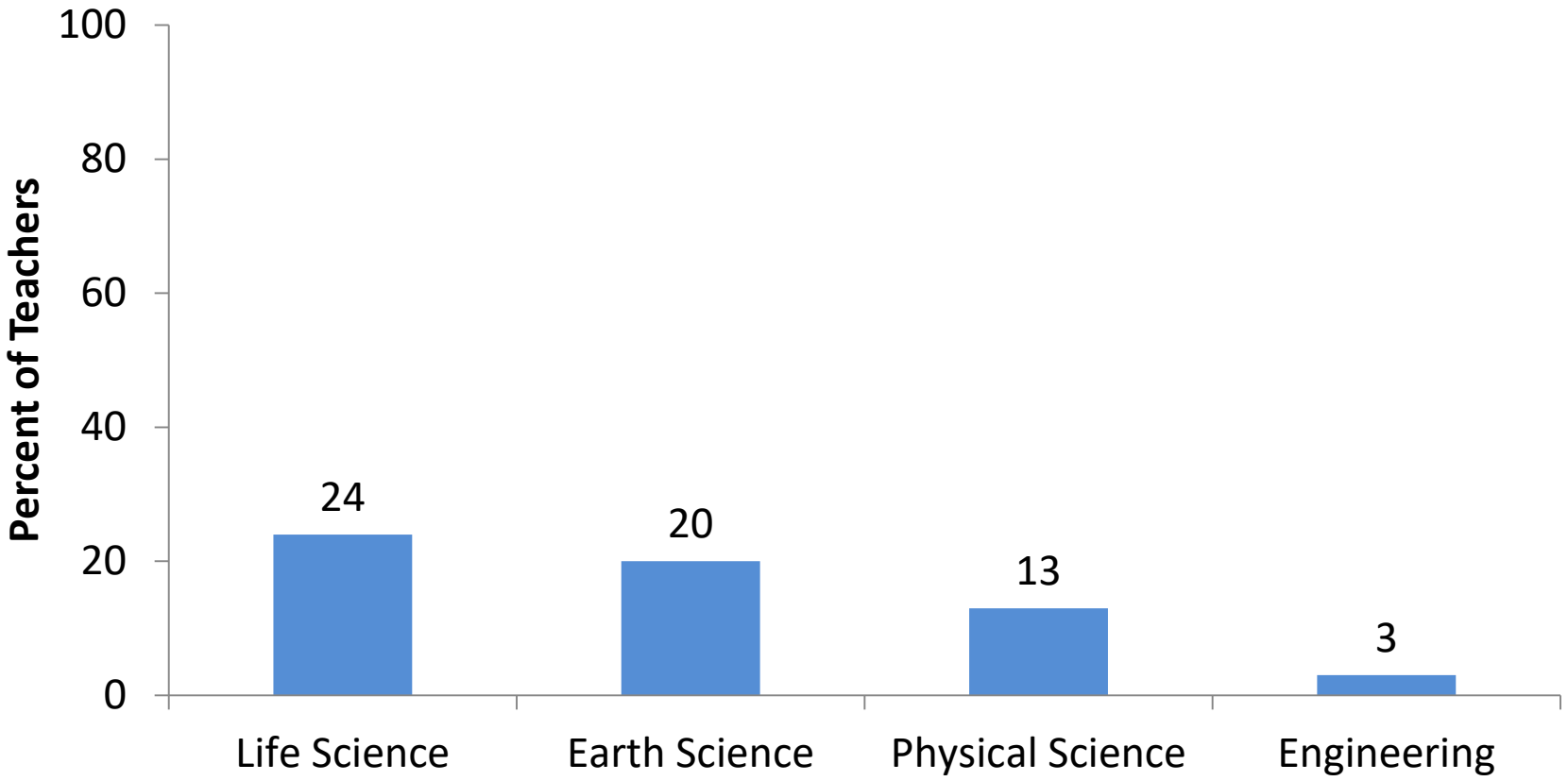


Teacher Independent Variables

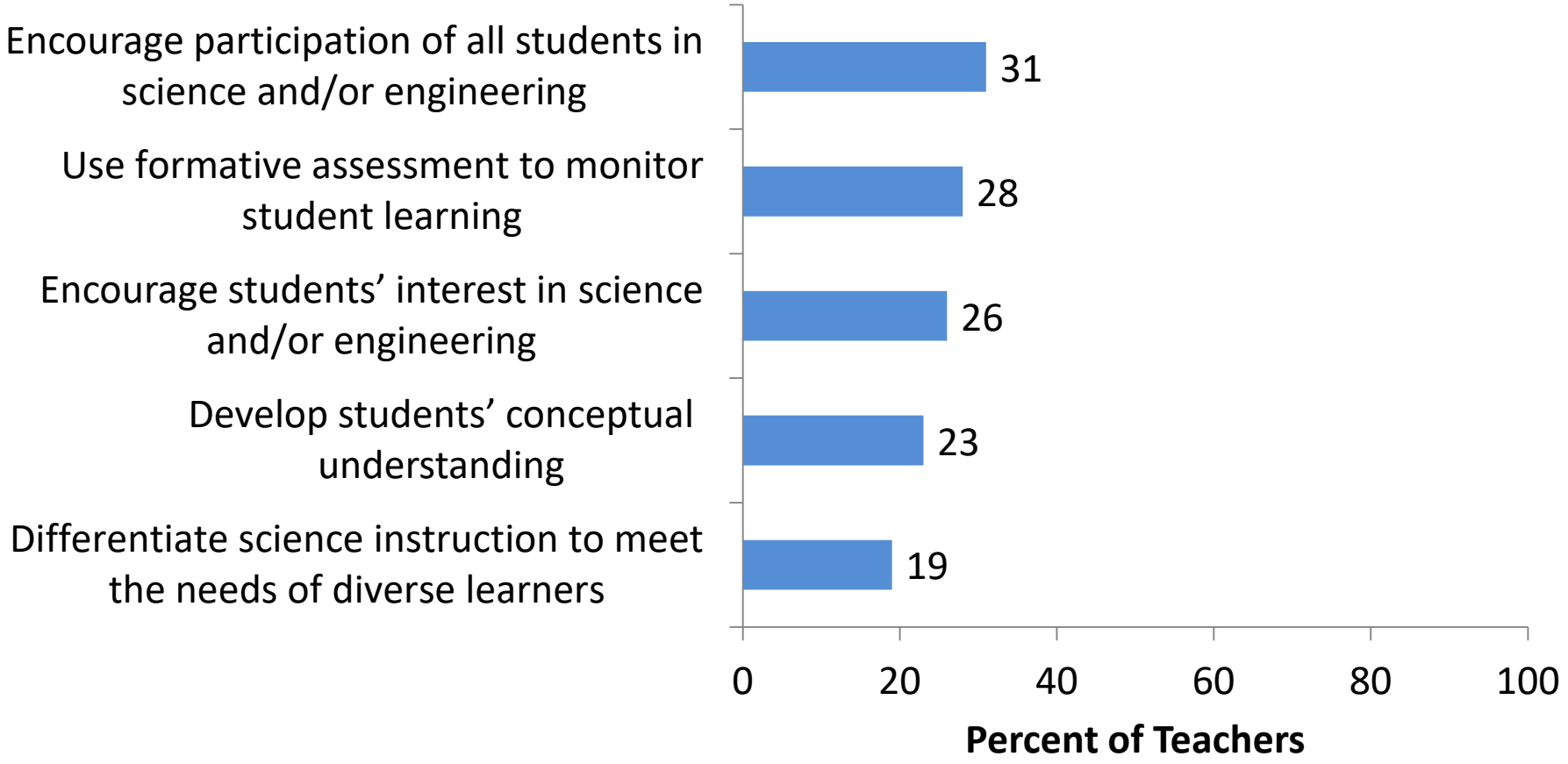
K–12 Science Teaching Experience



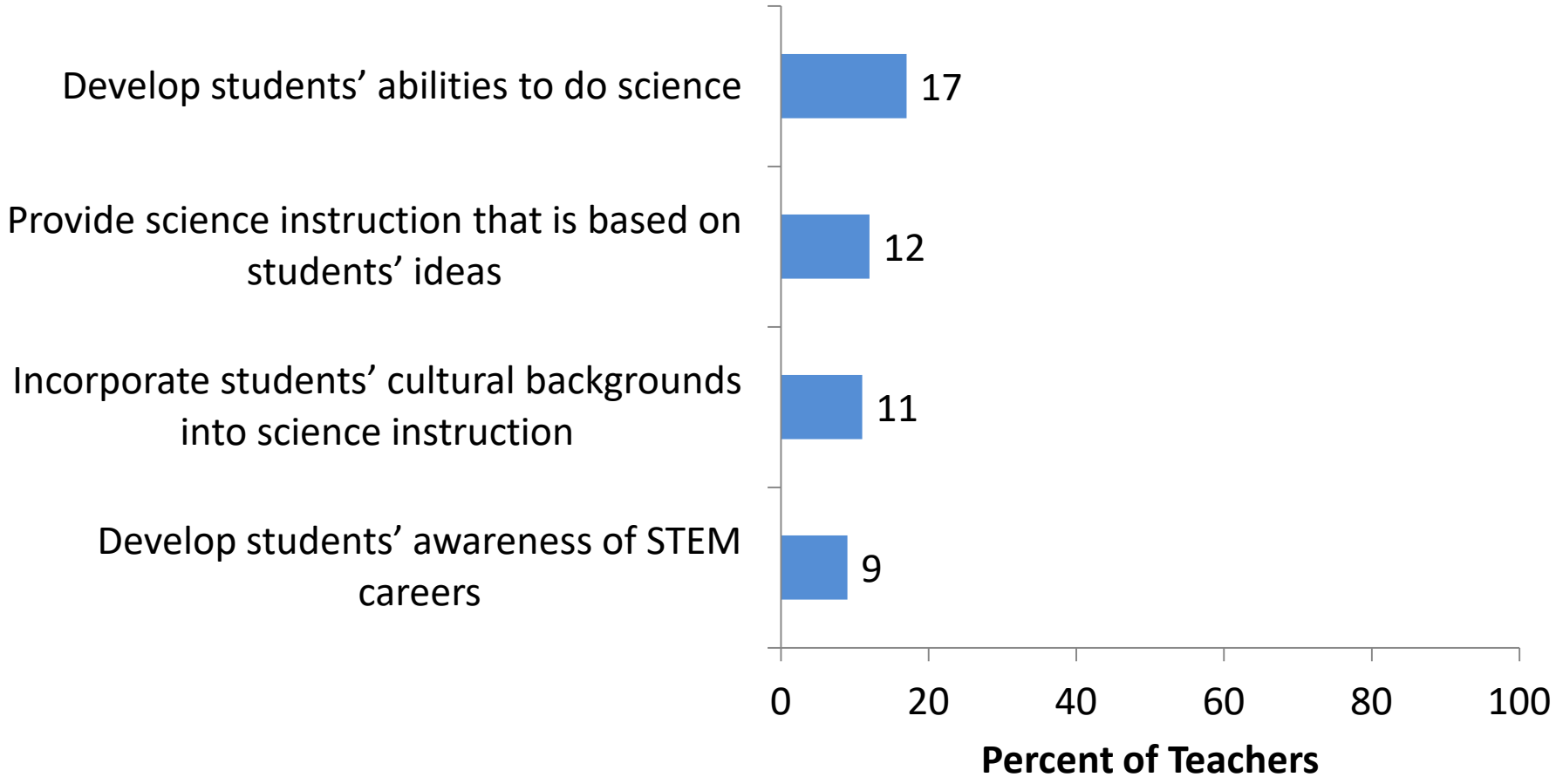
Perceptions of Preparedness: Very Well Prepared to Teach Science Topics



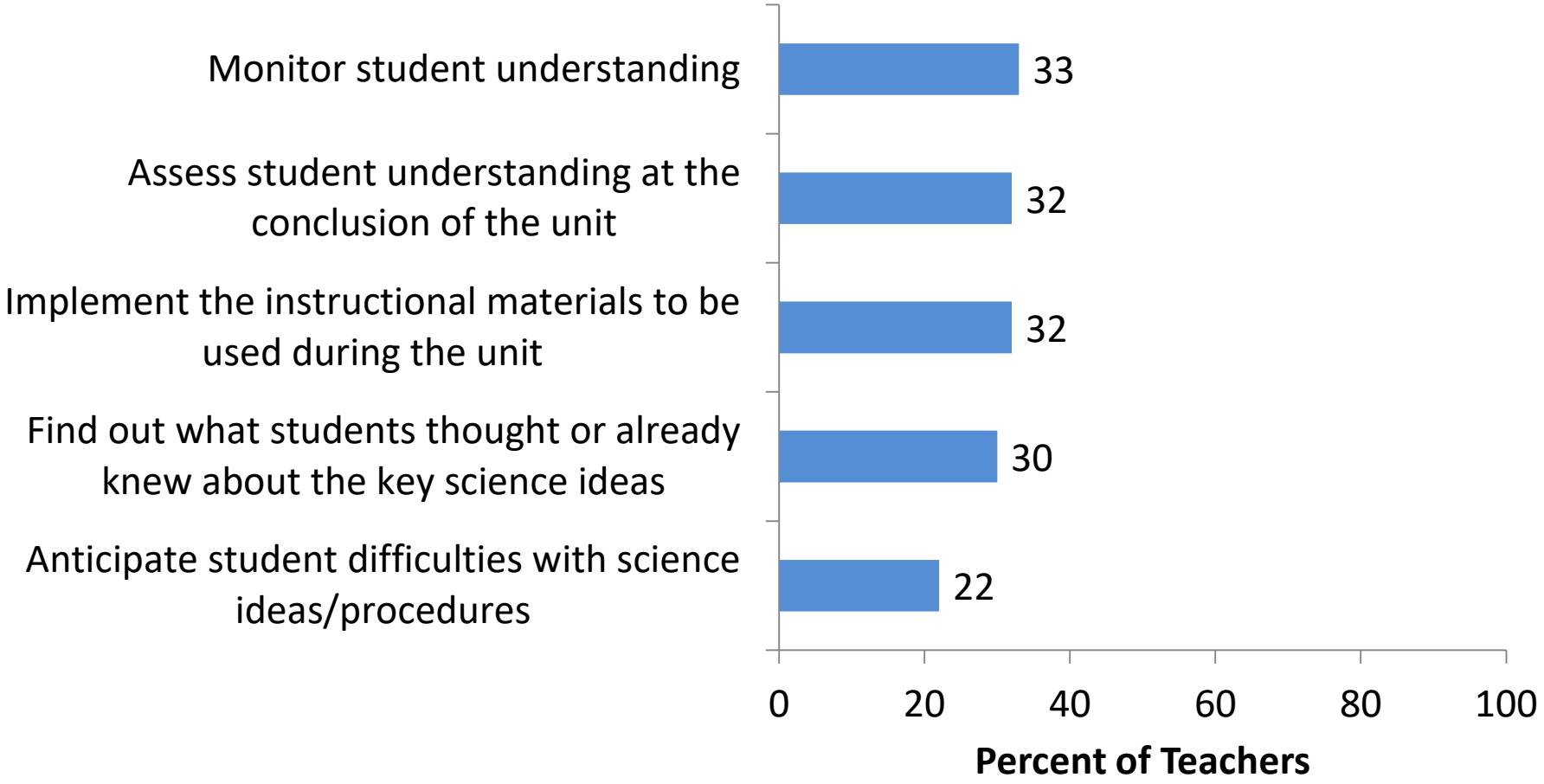
Perceptions of Preparedness: Very Well Prepared to Use Student-Centered Pedagogies



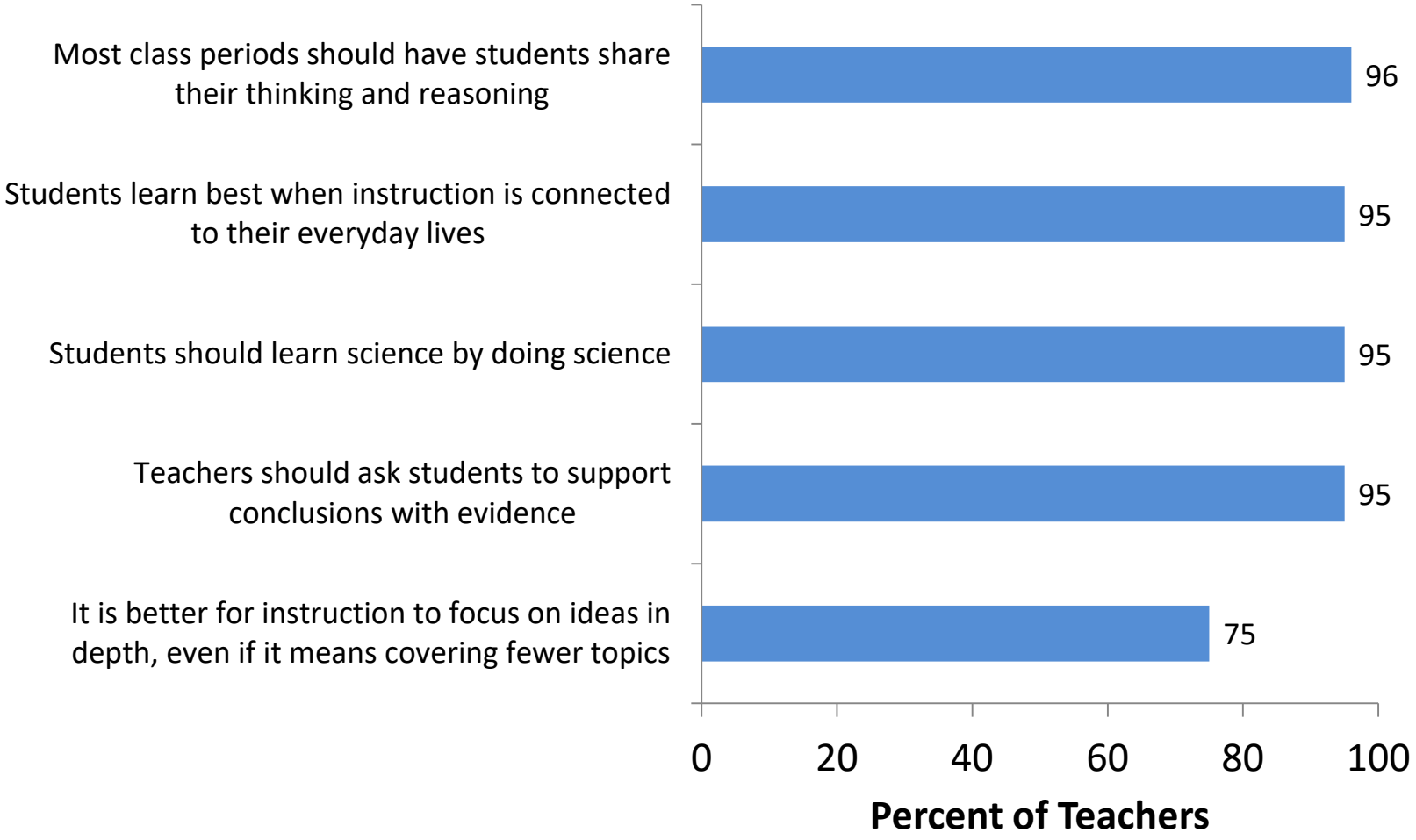
Perceptions of Preparedness: Very Well Prepared to Use Student-Centered Pedagogies



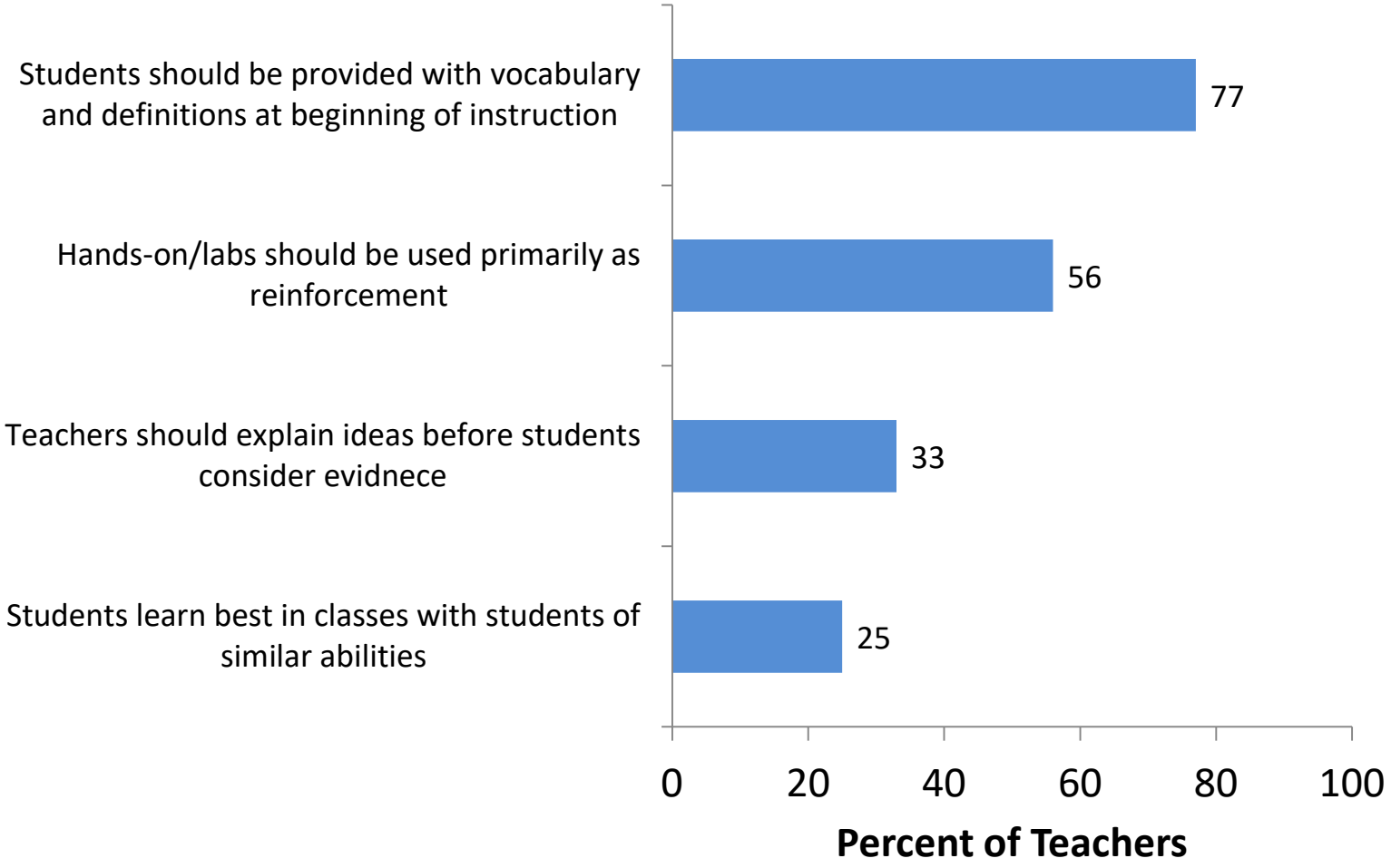
Perceptions of Preparedness: Very Well Prepared for Various Tasks in the Most Recent Unit



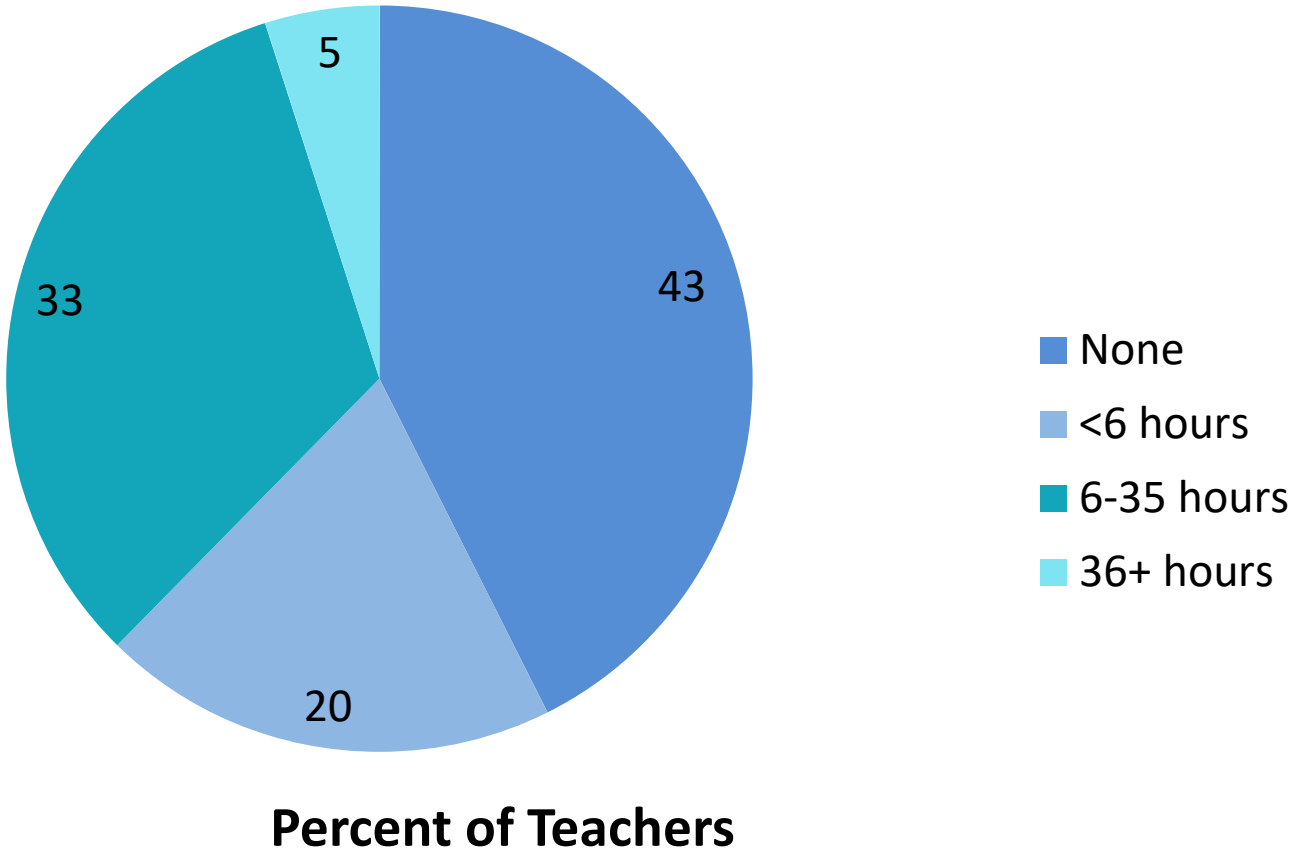
Teachers Agreeing With Various Reform-Oriented Teaching Beliefs



Teachers Agreeing With Various Traditional Teaching Beliefs

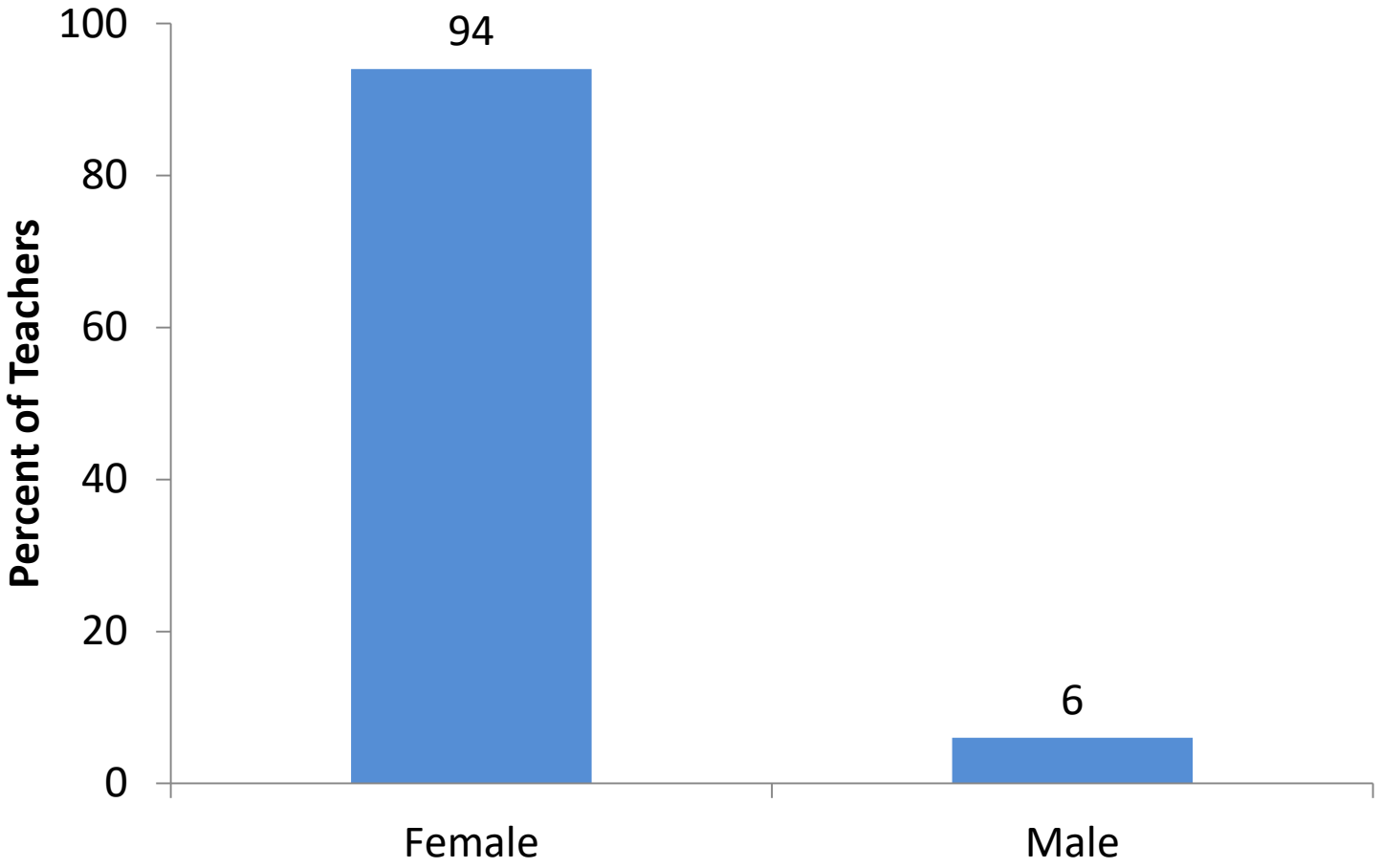


Hours of Science PD in the Previous 3 Years

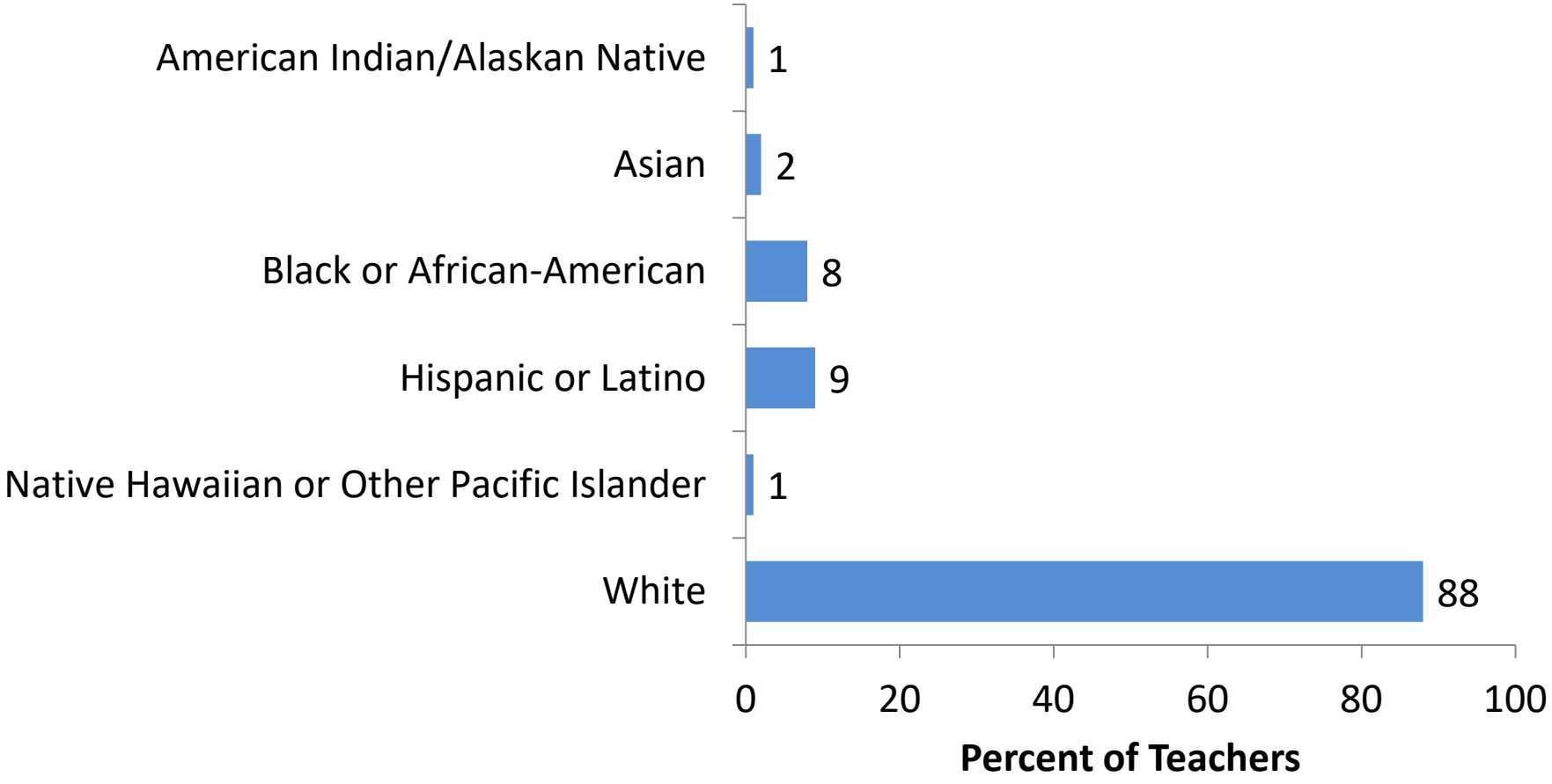


Percent of Teachers

Teacher Characteristics

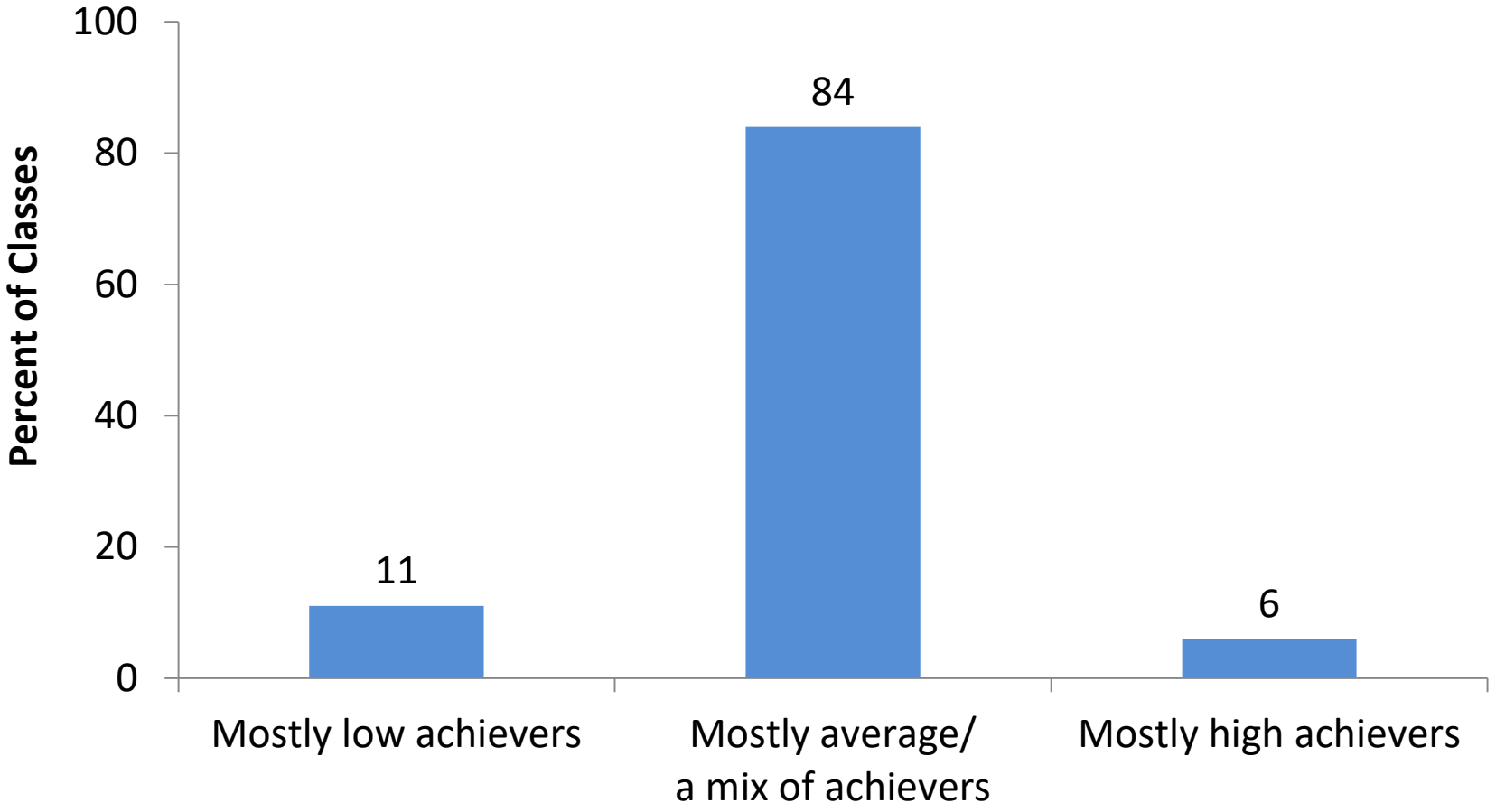


Teacher Race/Ethnicity

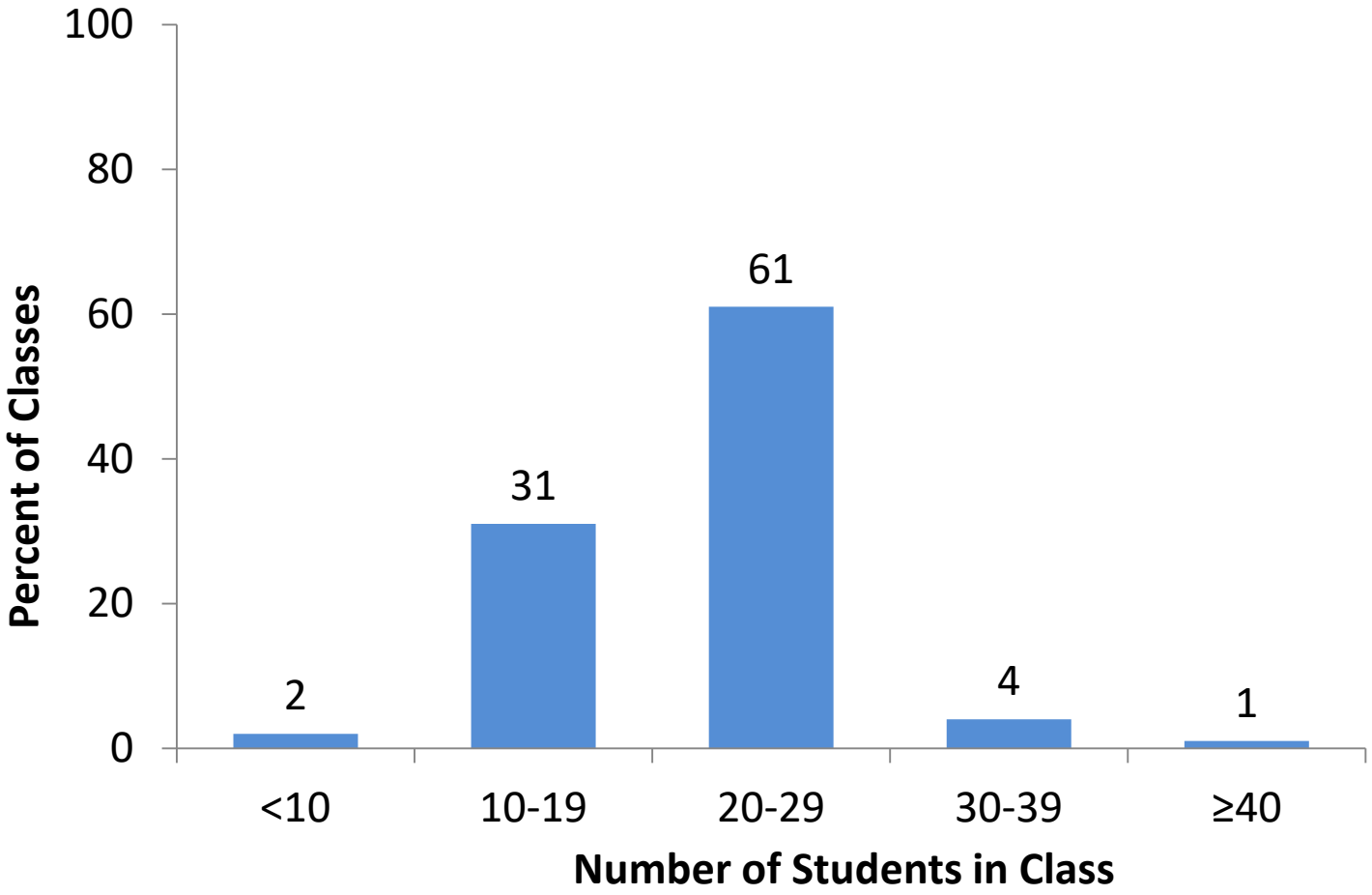


Class Independent Variables

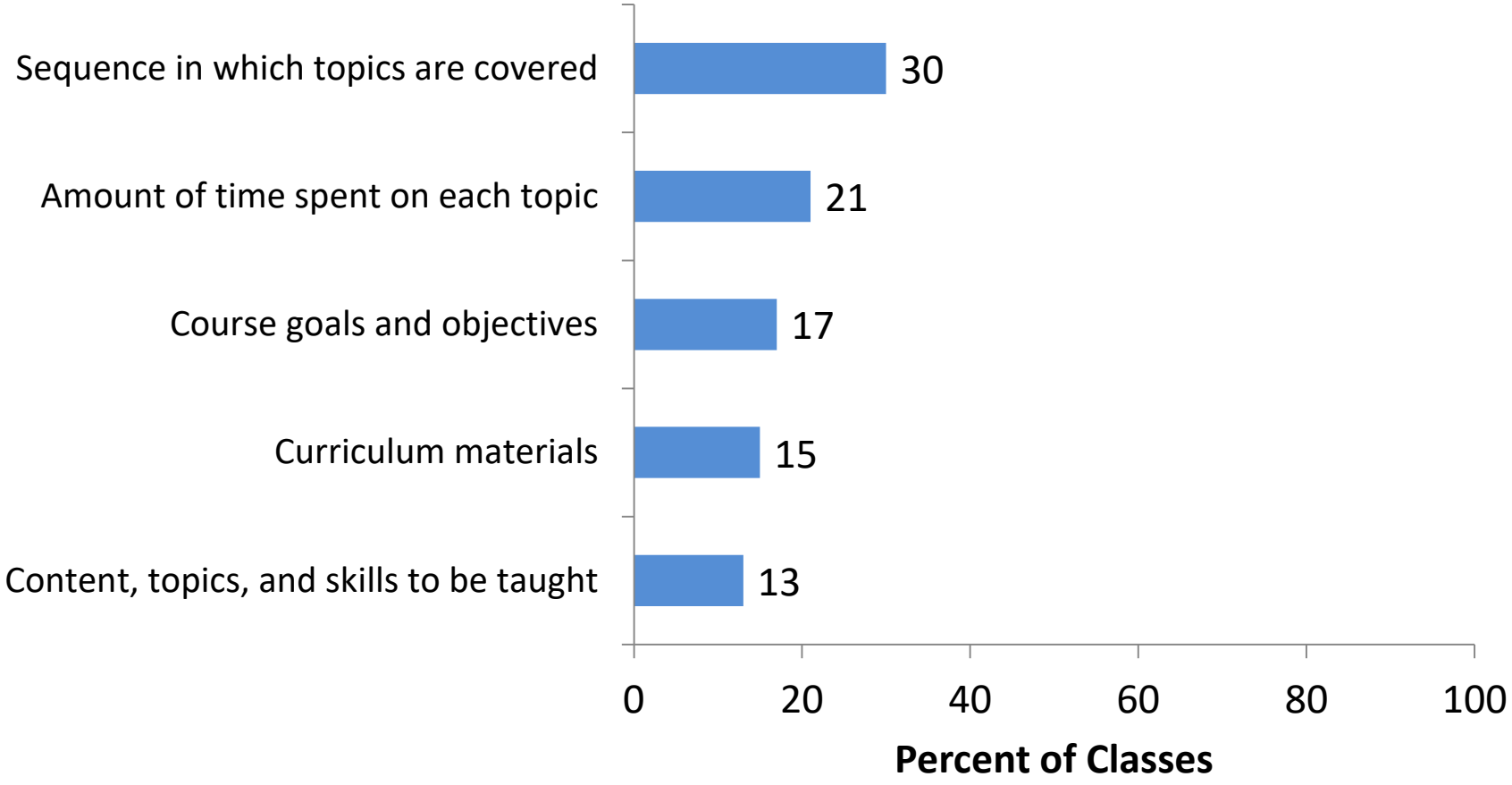
Prior Achievement Grouping in Science Classes



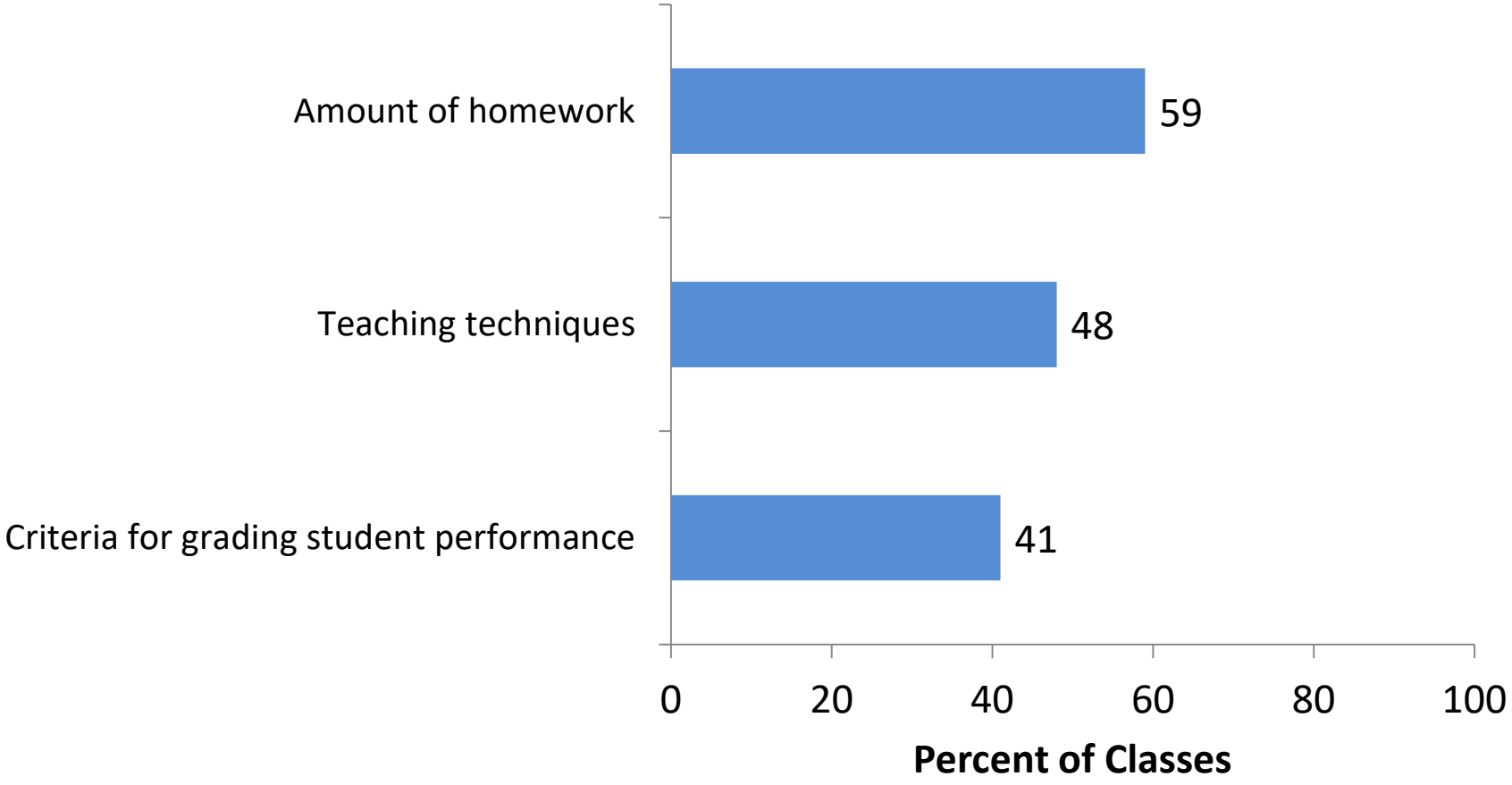
Class Size


100
80
60
40
20
0
Percent of Classes
2
31
61
4
1
<10
10-19
20-29
30-39
≥40
Number of Students in Class

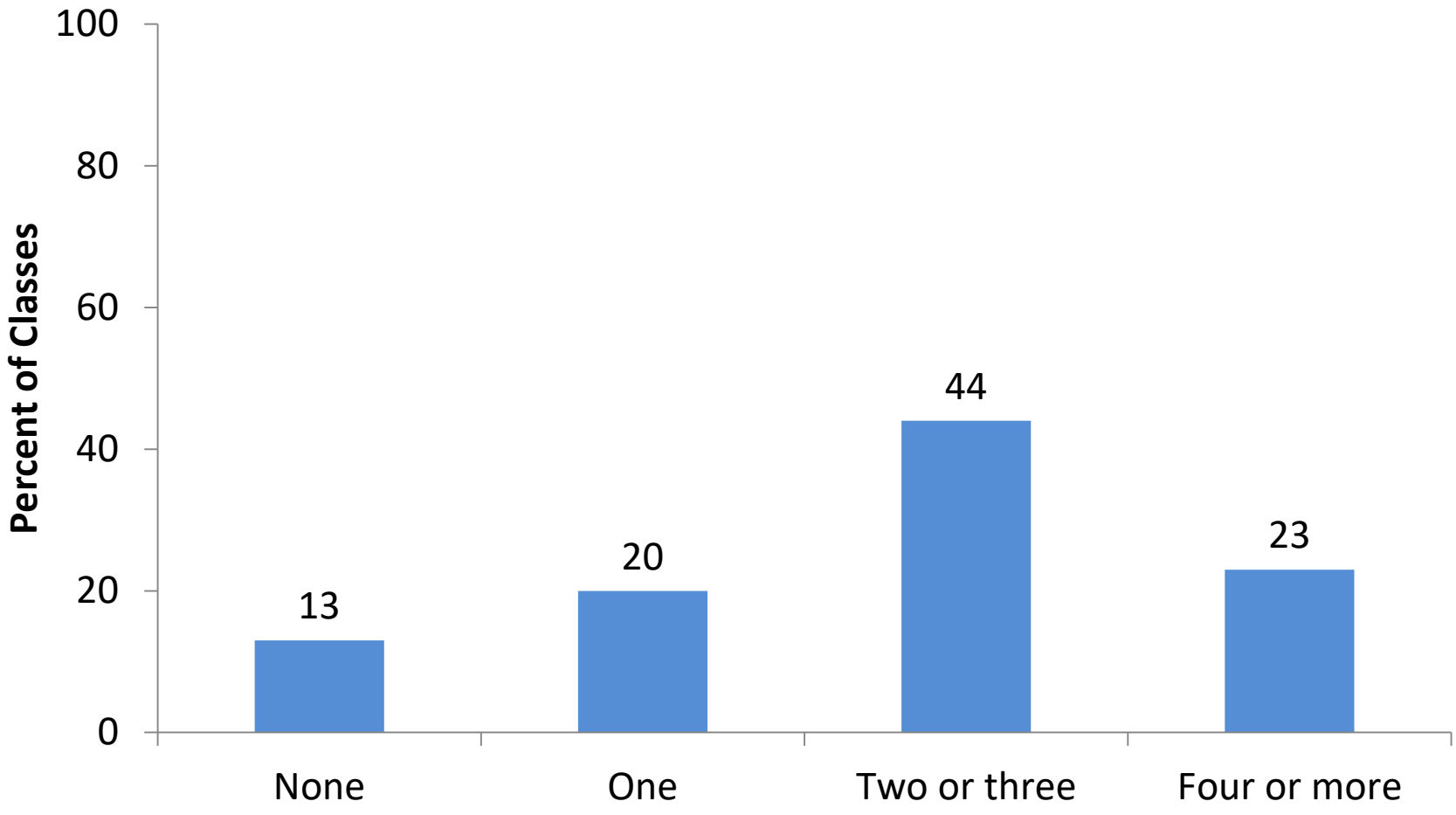
Classes in Which Teachers Feel Strong Control Over Curriculum



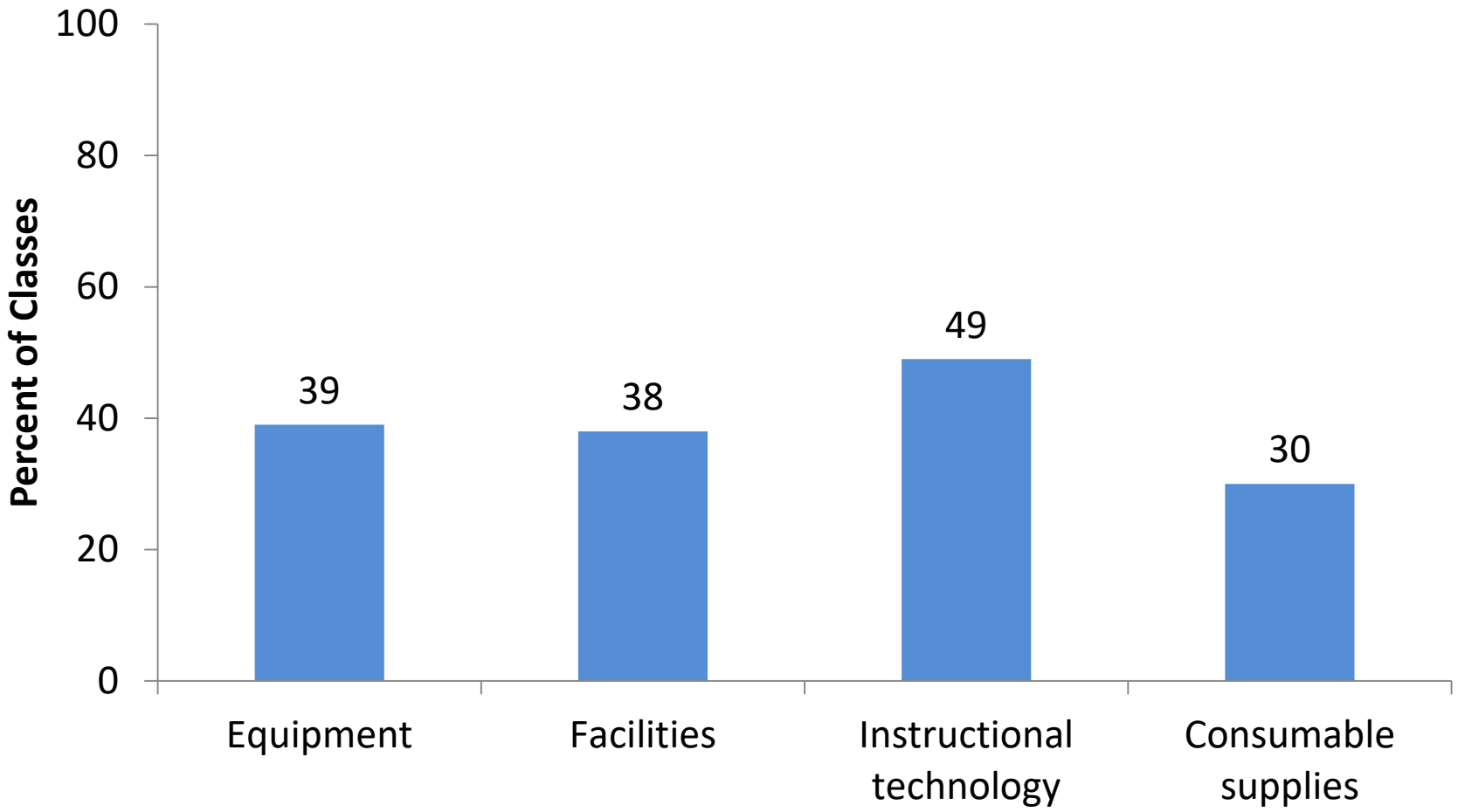
Classes in Which Teachers Feel Strong Control Over Pedagogy



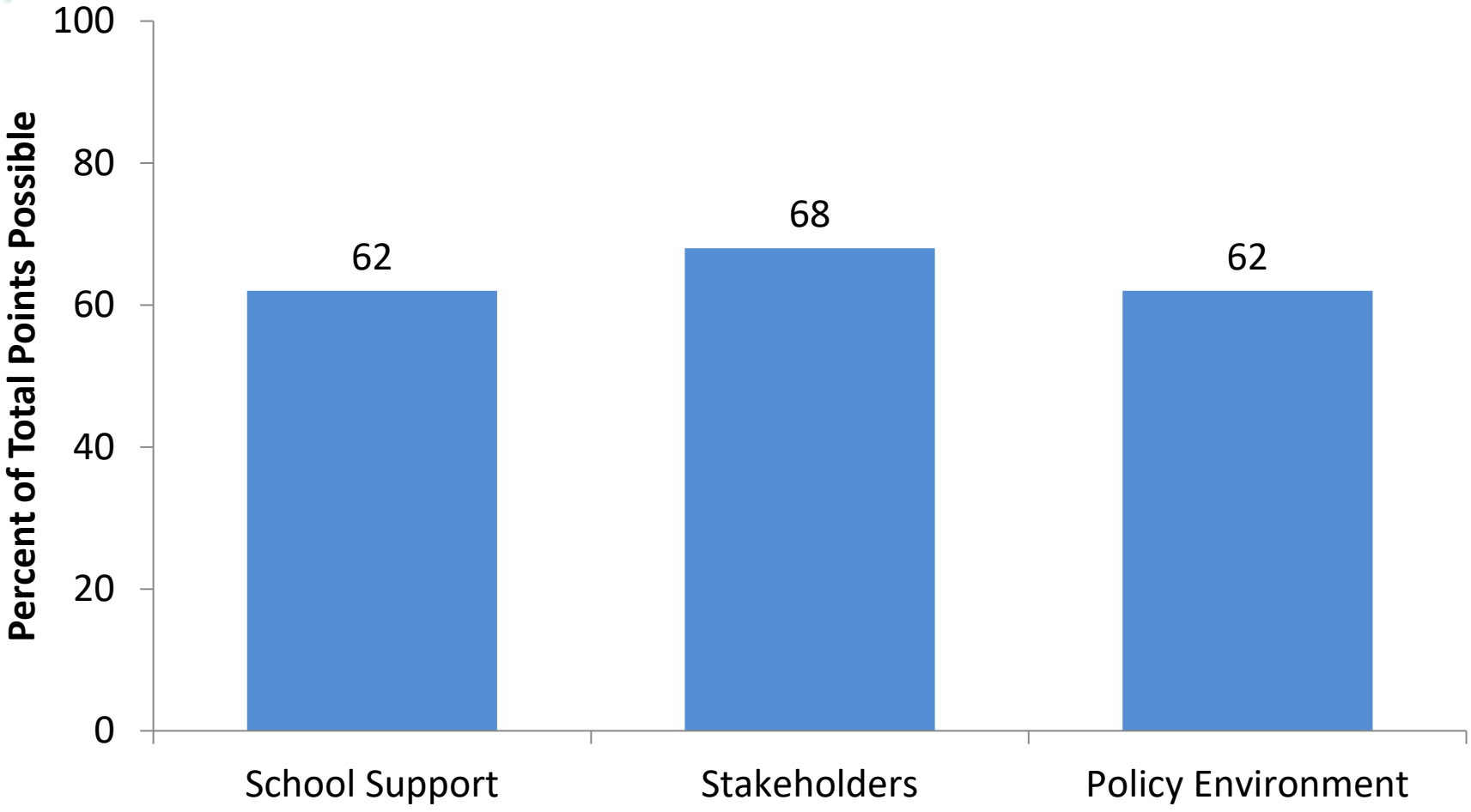
Number of Types of Instructional Materials Used Often



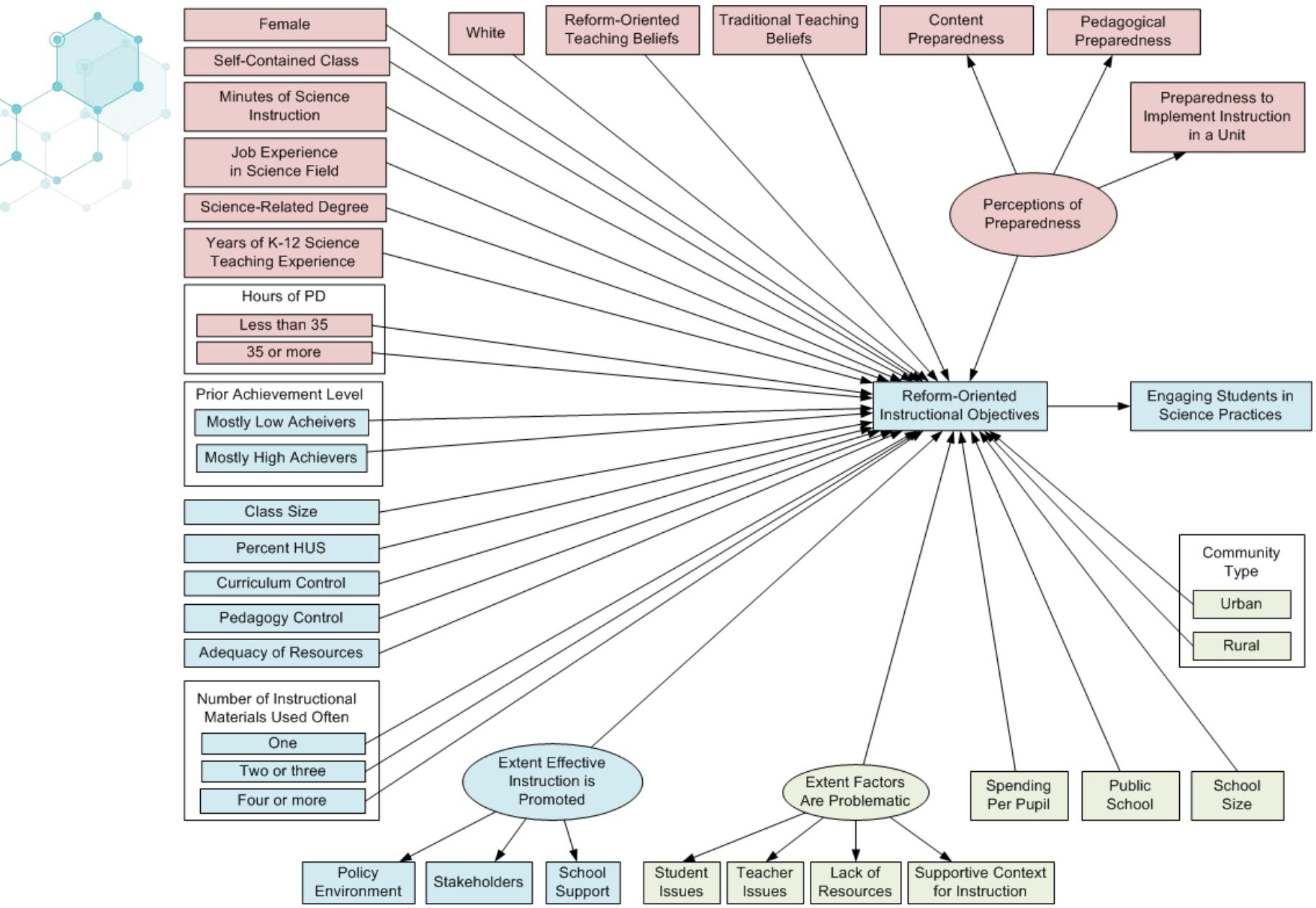
Classes in Which Teachers Feel Various Resources are Adequate

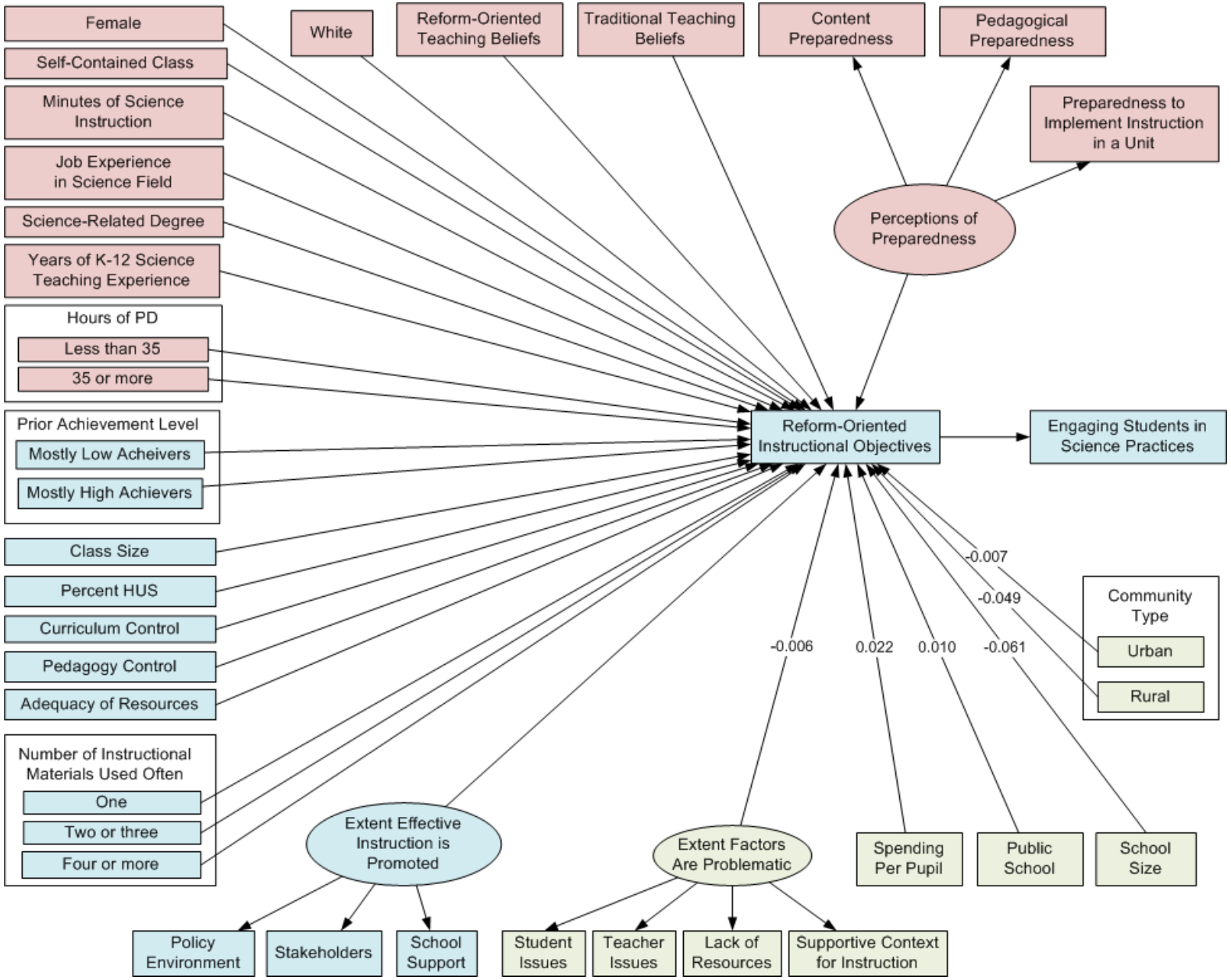


Class Mean Scores for Factors Promoting Effective Instruction Composites



Path Model


Female
Self-Contained Class
Minutes of Science Instruction
Job Experience in Science Field
Science-Related Degree
Years of K-12 Science Teaching Experience
Hours of PD
Less than 35
35 or more
Prior Achievement Level
Mostly Low Acheivers
Mostly High Achievers
Class Size
Percent HUS
Curriculum Control
Pedagogy Control
Adequacy of Resources
Number of Instructional Materials Used Often
One
Two or three
Four or more
White
Reform-Oriented Teaching Beliefs
Traditional Teaching Beliefs
Content Preparedness
Pedagogical Preparedness
Preparedness to Implement Instruction in a Unit
Perceptions of Preparedness
Reform-Oriented Instructional Objectives
Engaging Students in Science Practices
Community Type
Urban
Rural
Spending Per Pupil
Public School
School Size
Extent Effective Instruction is Promoted
Policy Environment
Stakeholders
School Support
Extent Factors Are Problematic
Student Issues
Teacher Issues
Lack of Resources
Supportive Context for Instruction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Traditional Teaching Beliefs
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Pedagogical Preparedness
Preparedness to Implement Instruction in a Unit
Perceptions of Preparedness
Reform-Oriented Instructional Objectives
Engaging Students in Science Practices
-0.007
-0.049
-0.006
0.022
0.010
-0.061
Community Type
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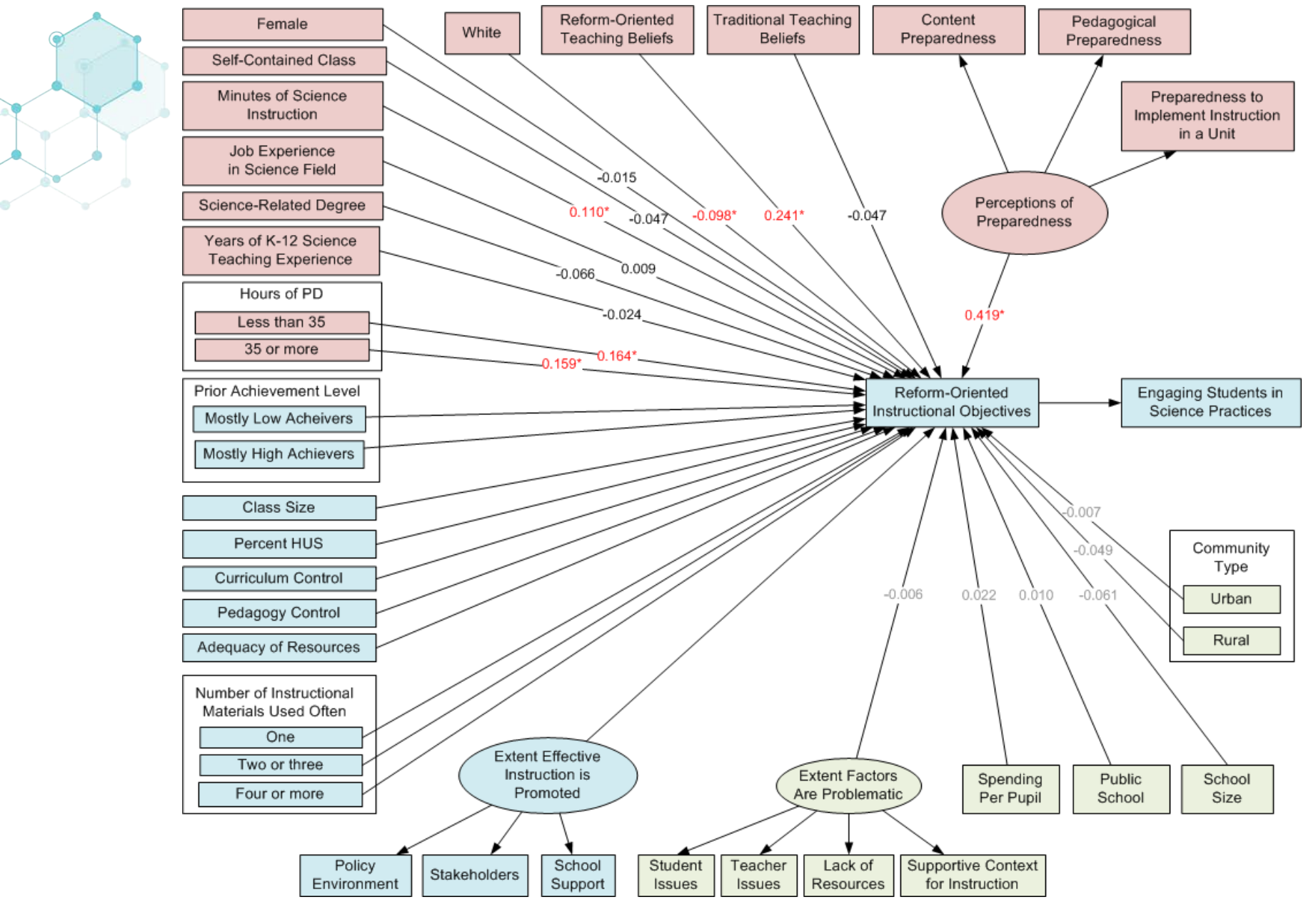
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Pedagogical Preparedness
Preparedness to Implement Instruction in a Unit
Perceptions of Preparedness
-0.015
0.110*
-0.047
-0.098*
0.241*
-0.047
-0.066
0.009
-0.024
0.419*
0.159*
0.164*
Reform-Oriented Instructional Objectives
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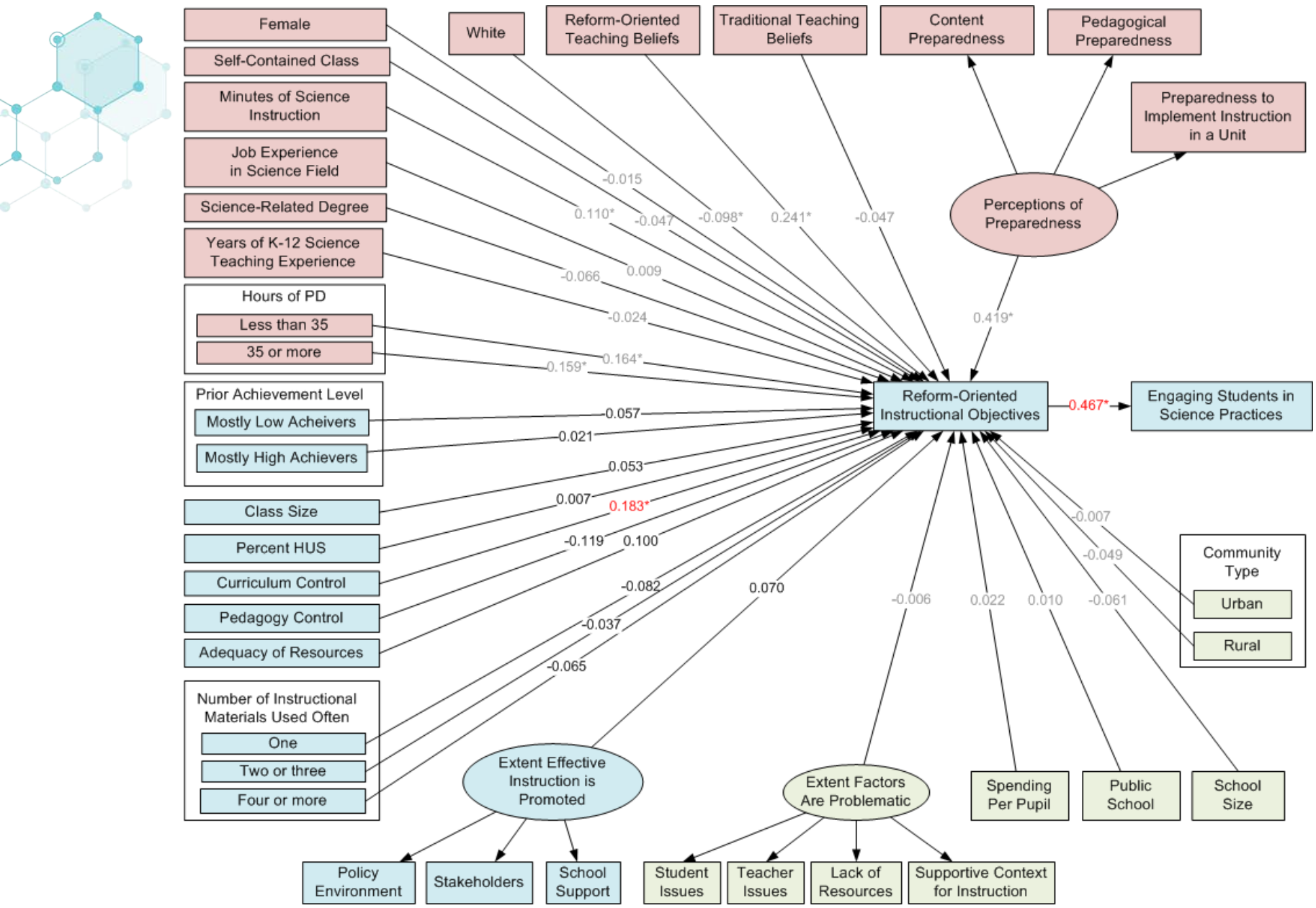
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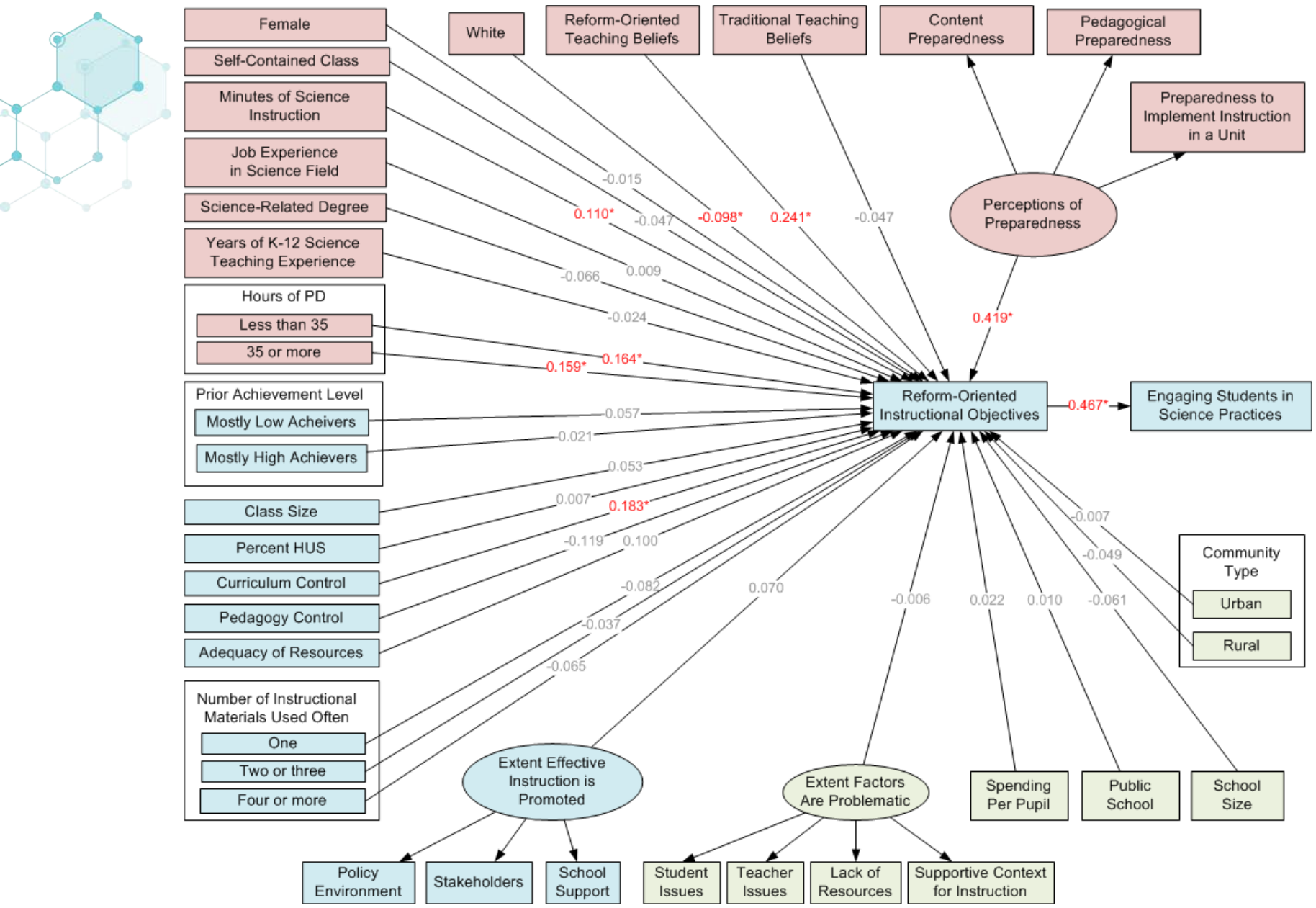
0.159*
0.164*
0.057
0.021
0.053
0.007
0.183*
-0.119
0.100
-0.082
-0.037
-0.065
0.070
-0.006
0.022
0.010
-0.061
-0.007
-0.049
0.467*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0.110*
-0.047
-0.098*
0.241*
-0.047
-0.066
0.009
-0.024
0.419*
0.159*
0.164*
-0.057
-0.021
0.053
0.007
0.183*
-0.119
0.100
-0.082
-0.037
-0.065
0.070
-0.006
0.022
0.010
-0.061
-0.007
-0.049
0.467*

Total Effects on Student Engagement in Science Practices

	Total Effect Size
Reform-Oriented Instructional Objectives	0.467
Perceptions of Preparedness	0.378
Minutes of science instruction	0.163
Traditional Teaching Beliefs	0.148
Class size	0.123
Curriculum Control	0.112
Pedagogy Control	-0.289
Adequacy of Resources for Instruction	0.279
Number of type of instructional materials used often (vs. none)	
One	0.018
Two or three	0.092
Four or more	0.139

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Differences Between Self-Contained and Non-Self-Contained Elementary Science Classes

P. Sean Smith

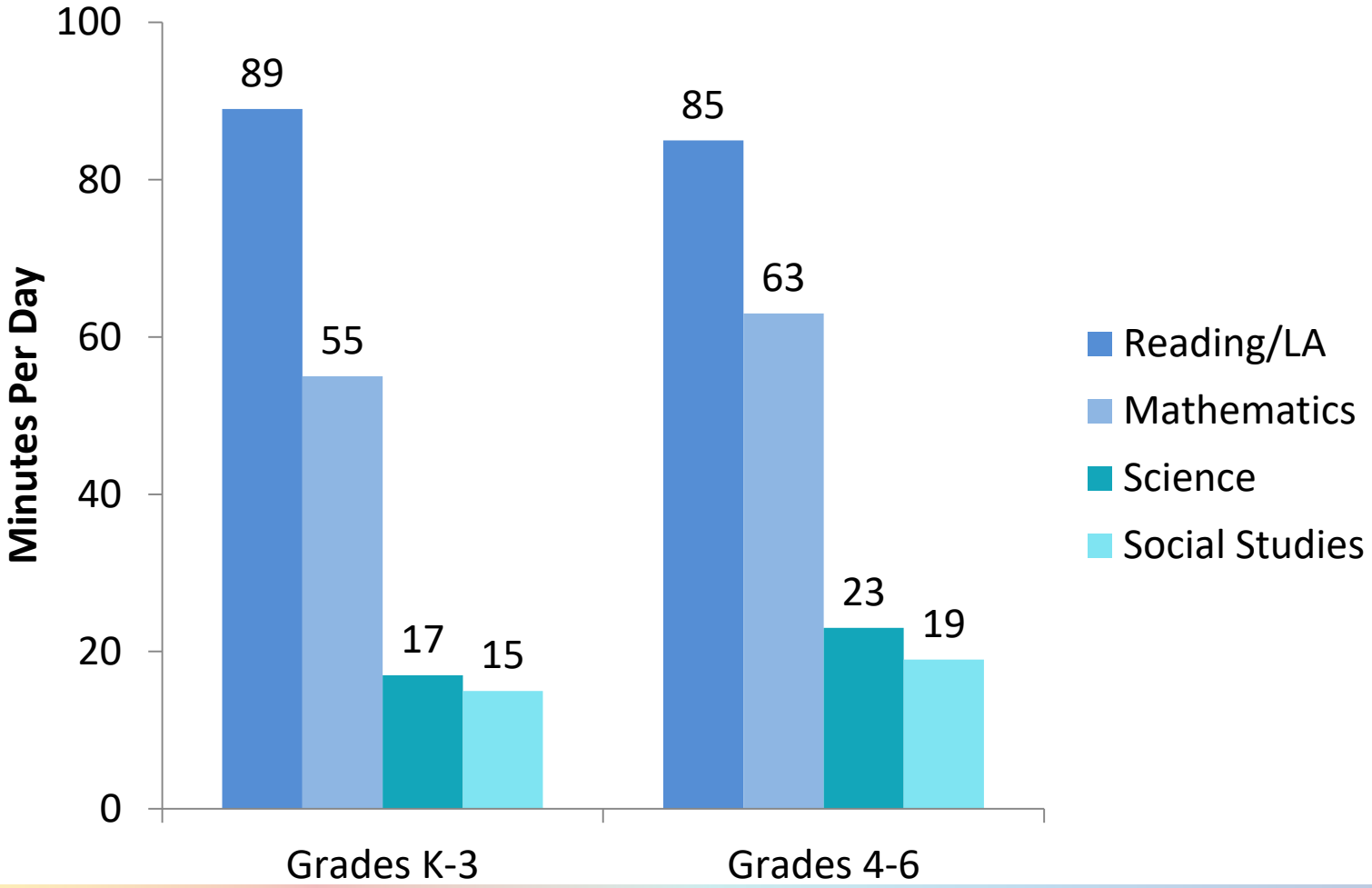
horizon RESEARCH, INC.

Background

More than 90% of elementary teachers work in self-contained settings (i.e., they teach multiple subjects to one group of students).

- Affordances include deep understanding of students and possibilities for integrating core subjects.
- Challenges include depth of preparation and accountability pressures across multiple subjects.
- Teachers have to make difficult choices about the amount of time they devote to each of the core subjects, and time for science often suffers.

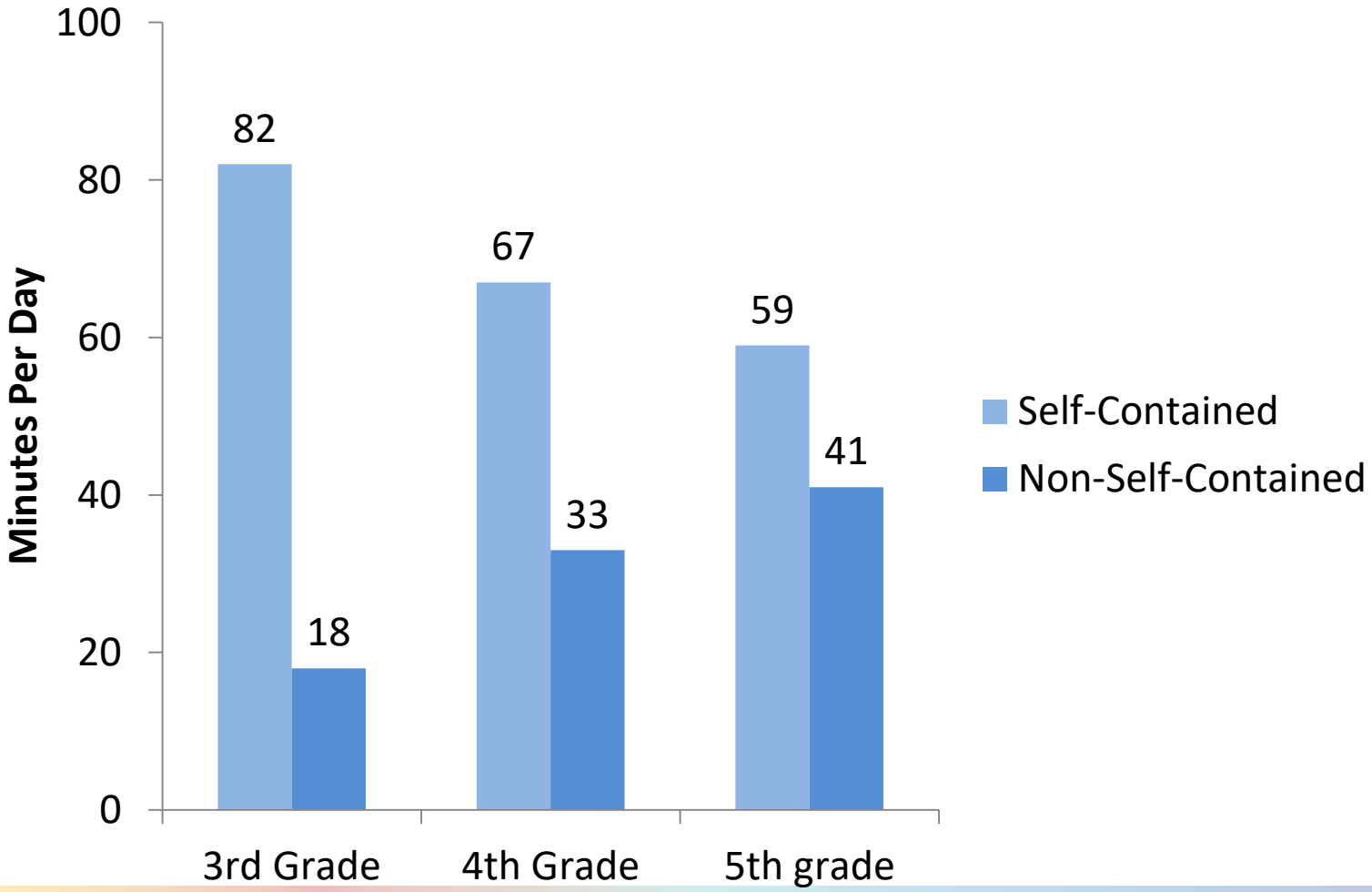
Instructional Time in Self-Contained Elementary Classes



Interestingly, between grades 3 and 5, science is increasingly likely to be taught in non-self-contained (NSC) settings.

- By NSC, we mean a teacher who teaches science to more than one group of students.
- Most frequently, NSC classes occur within a team-teaching model.
- Teachers of NSC classes are referred to as elementary content specialists in emerging literature (Markworth et al., 2016).

Science Class Structure: Grades 3-5

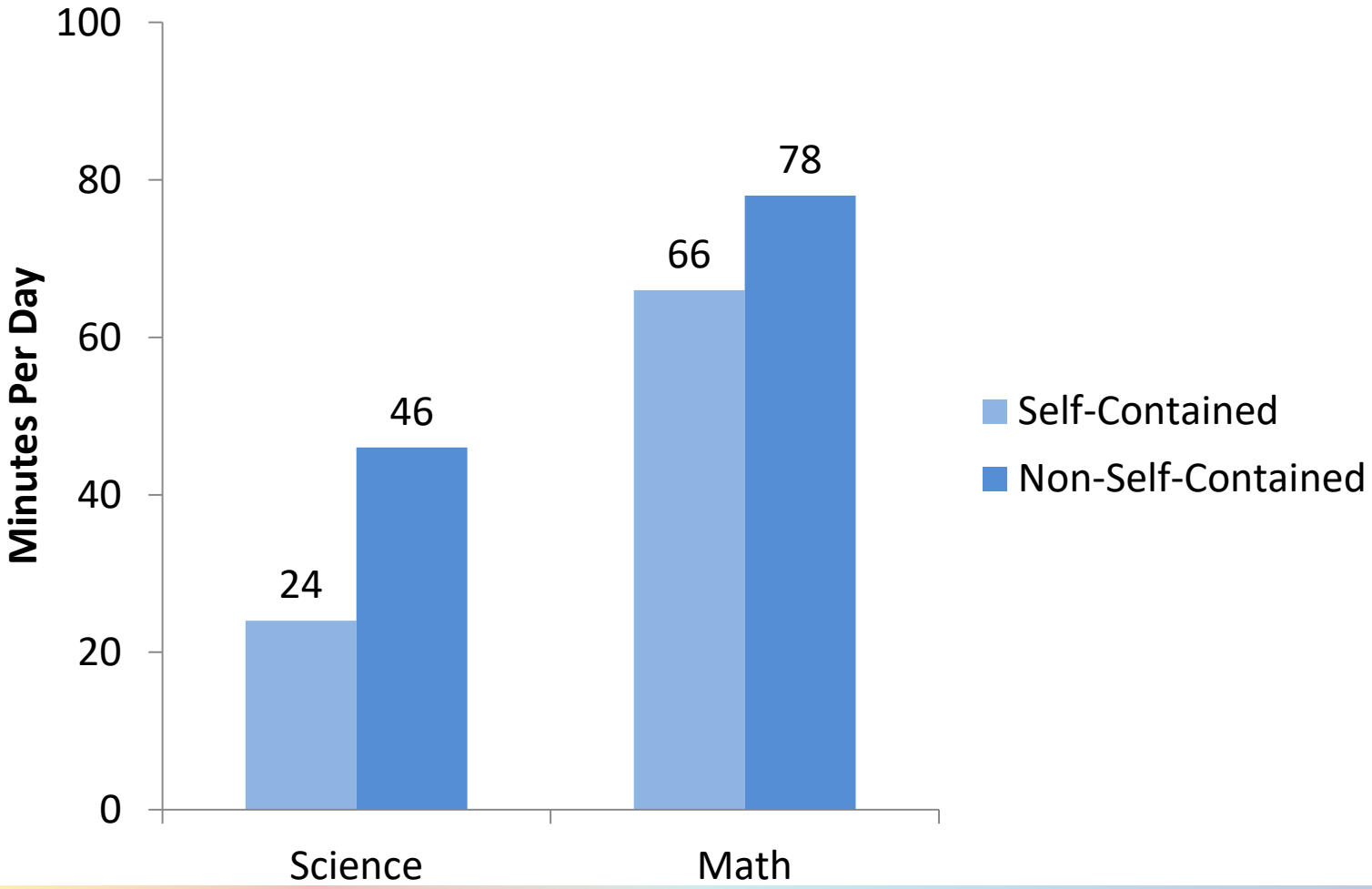


Science Instructional Time: Grades 3-5

Science instructional time in NSC classes is almost twice that in SC settings.

Further, the additional time does not seem to come from mathematics instruction.

Science and Math Instructional Time: Grades 3-5



Further Exploration

The sharp difference in time prompts questions about differences in other areas, including:

- Instruction
- Teacher Preparation
- School Context

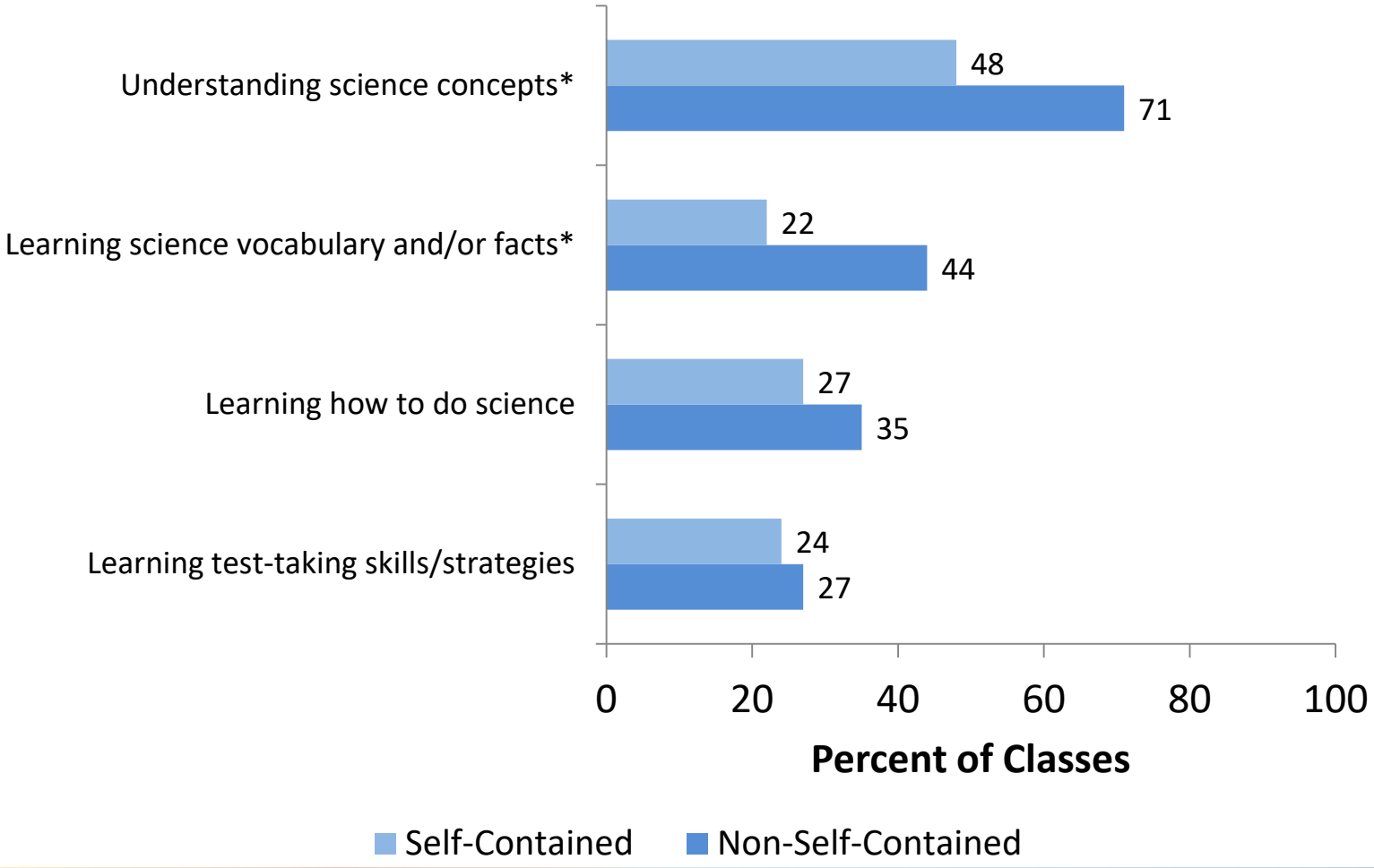
Note: In the charts that follow, an asterisk indicates a significant difference ($p < 0.05$) between SC and NSC.

Instructional Objectives

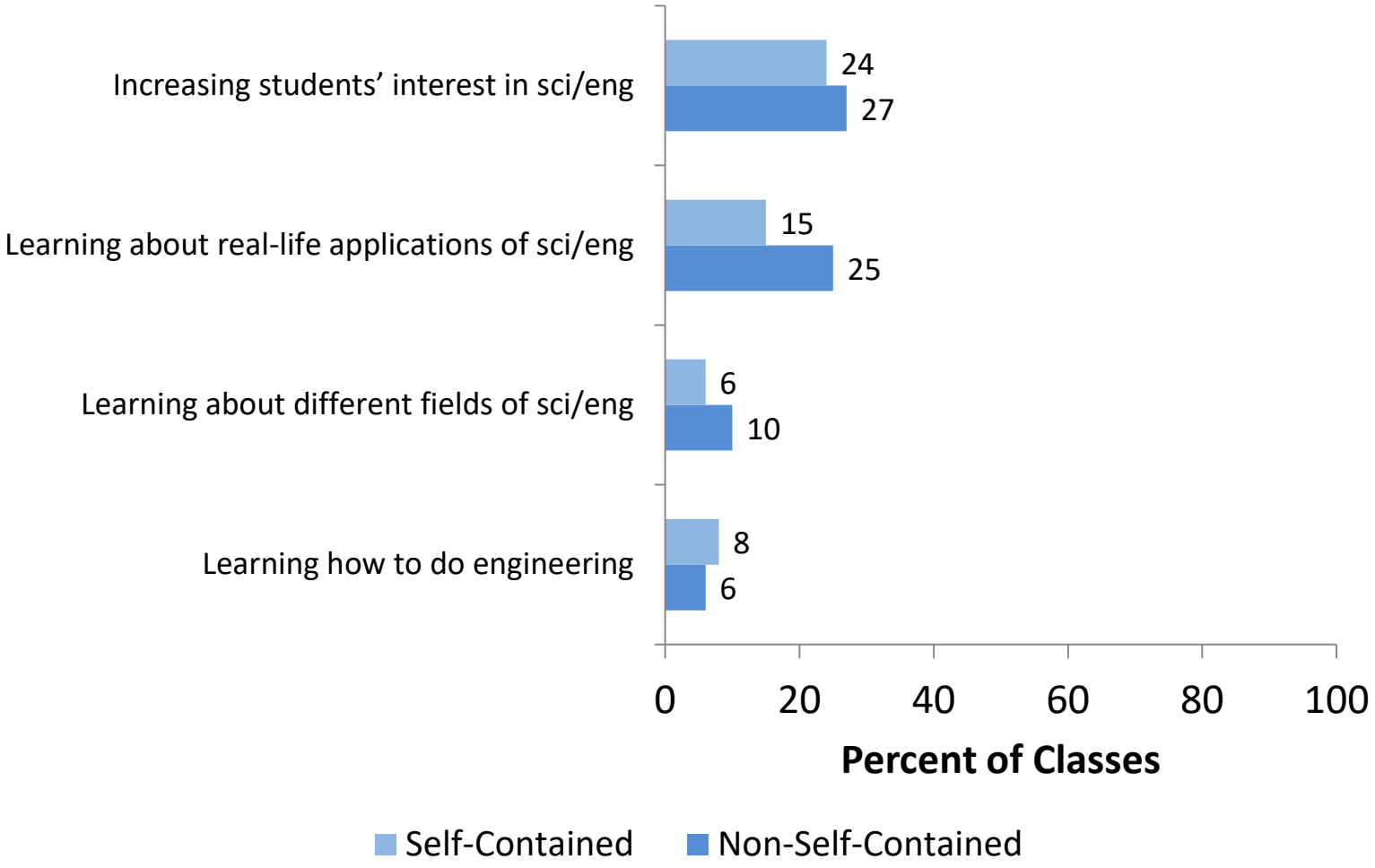
NSC science classes are much more likely than SC classes to emphasize:

- Understanding science concepts
- Learning science vocabulary and/or facts

Objectives Receiving a Heavy Emphasis



Objectives Receiving a Heavy Emphasis (cont)

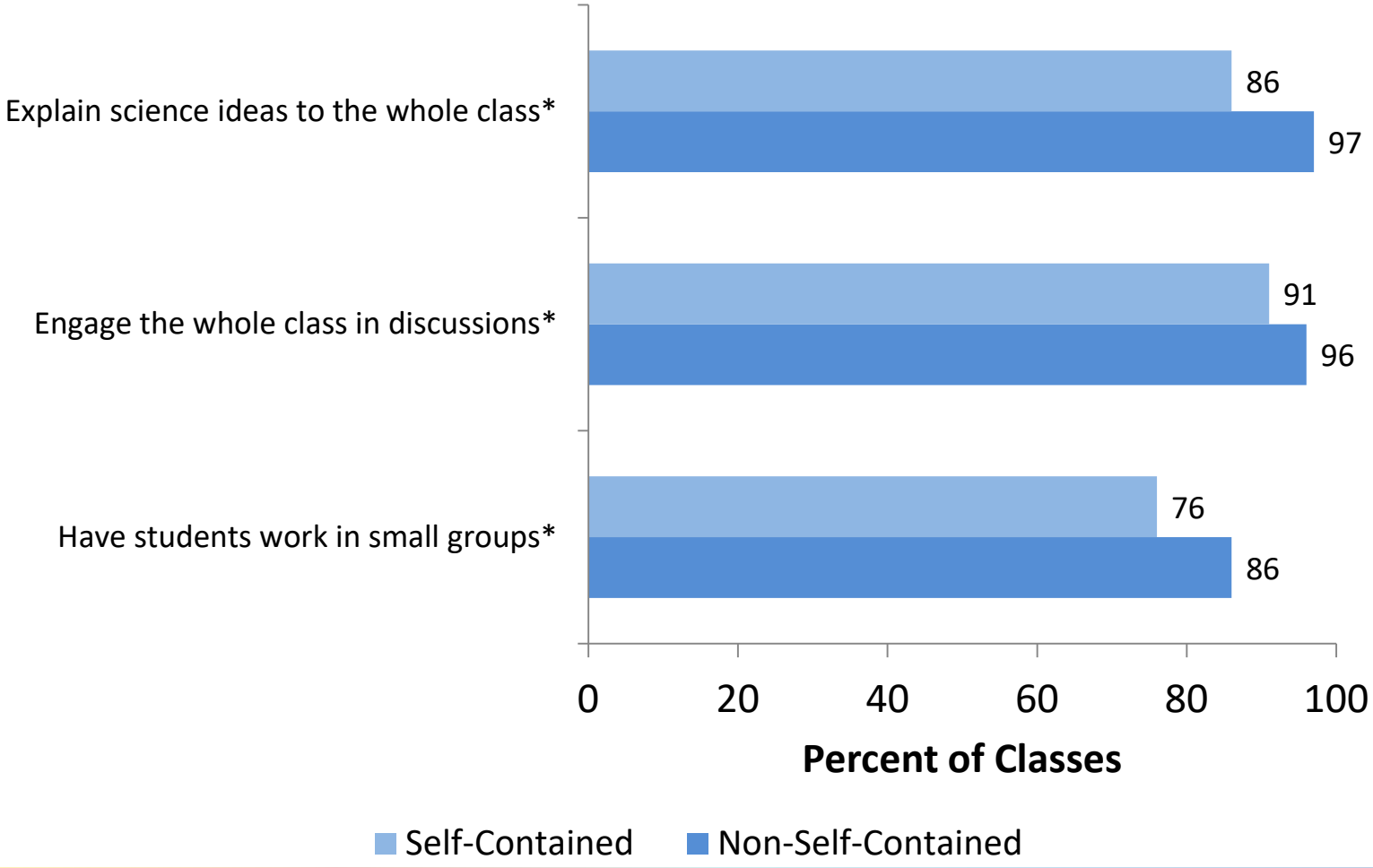


Science Class Activities

NSC science classes are more likely than SC classes to do the following activities:

- Explain science ideas to the whole class
- Engage the whole class in discussions
- Have students work in small groups

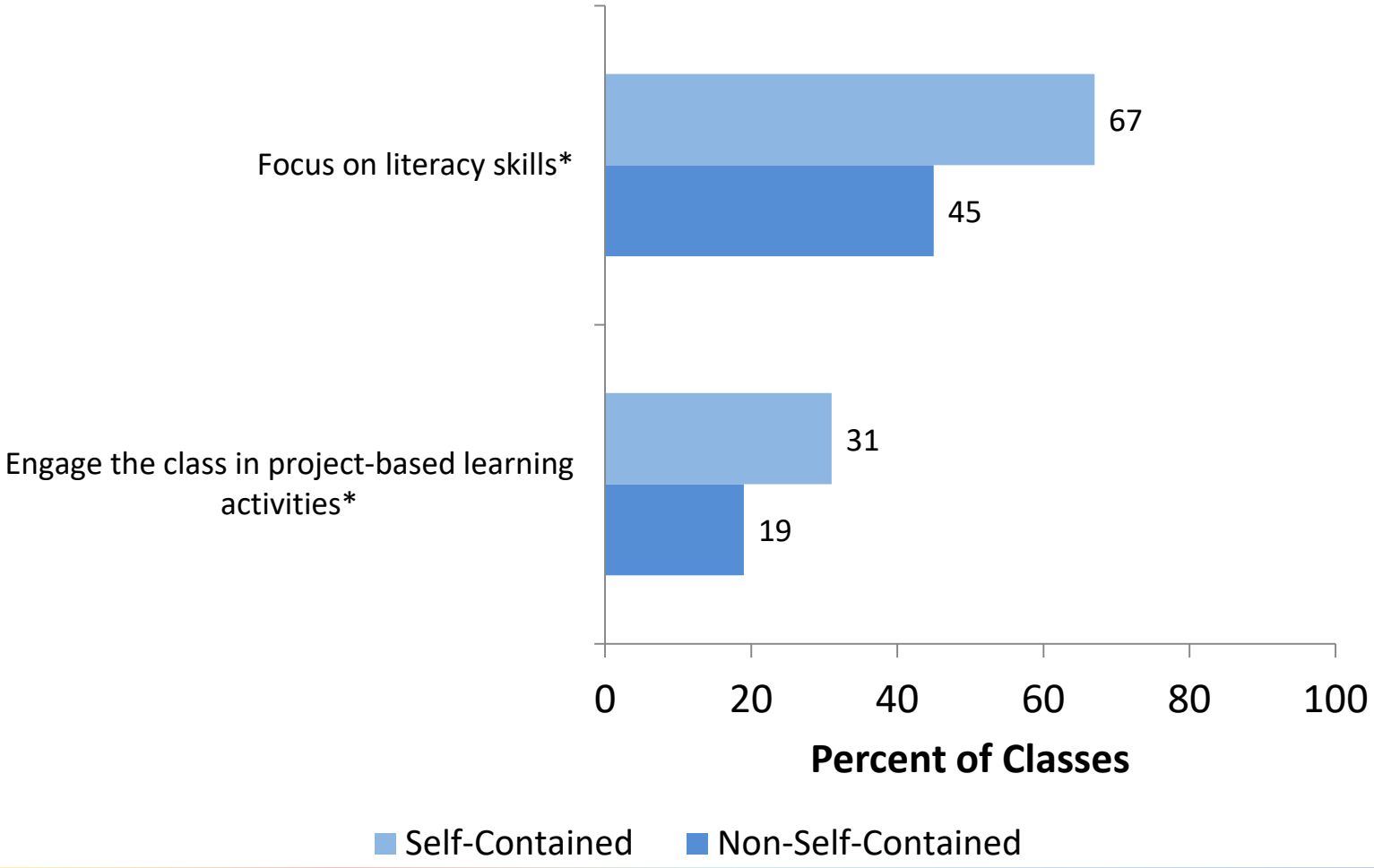
Science Class Activities: Weekly



NSC science classes were less likely than SC classes to do the following activities:

- Engage the class in project-based learning activities
- Focus on literacy skills

Science Class Activities: Weekly (cont)

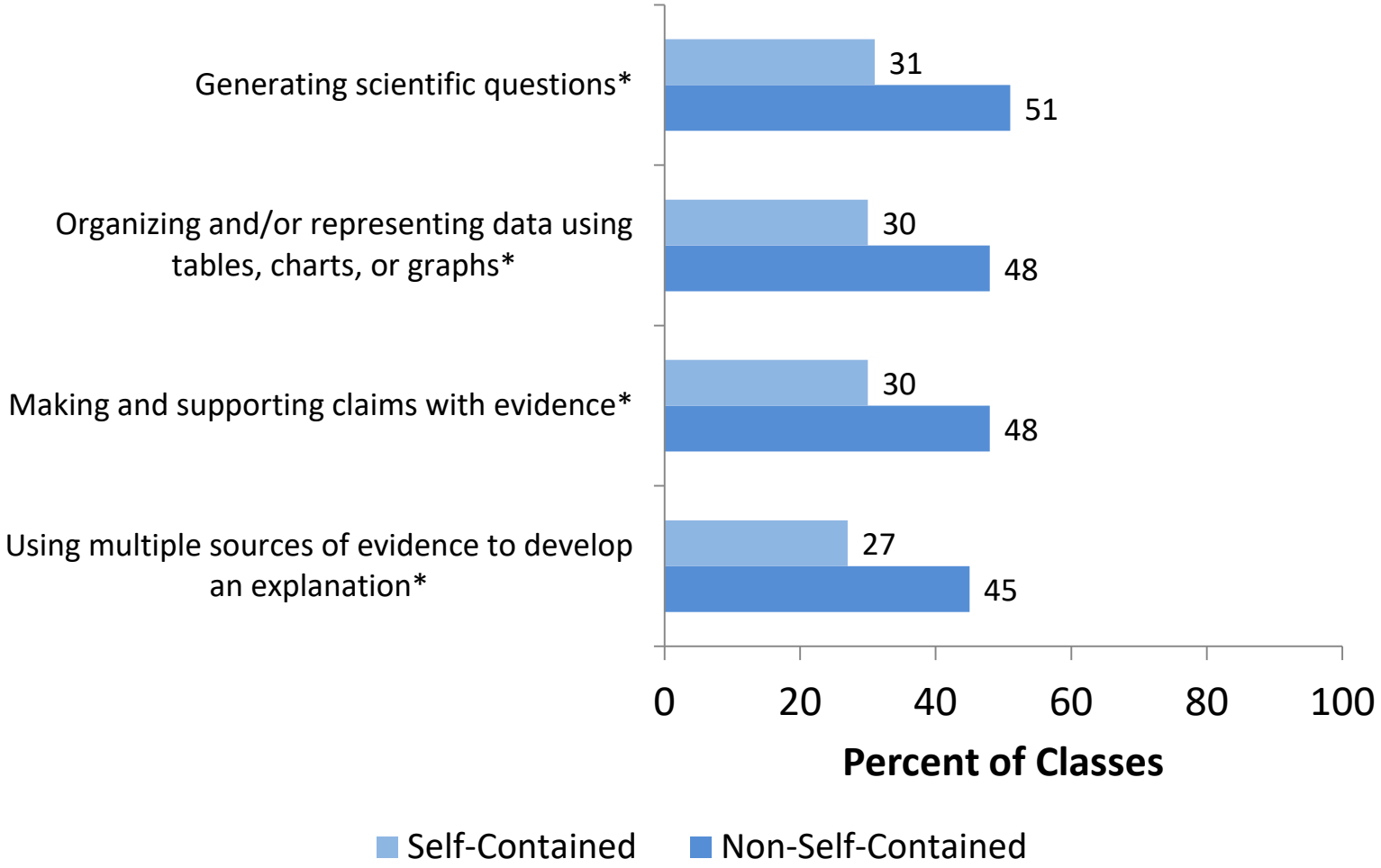


Science Practices

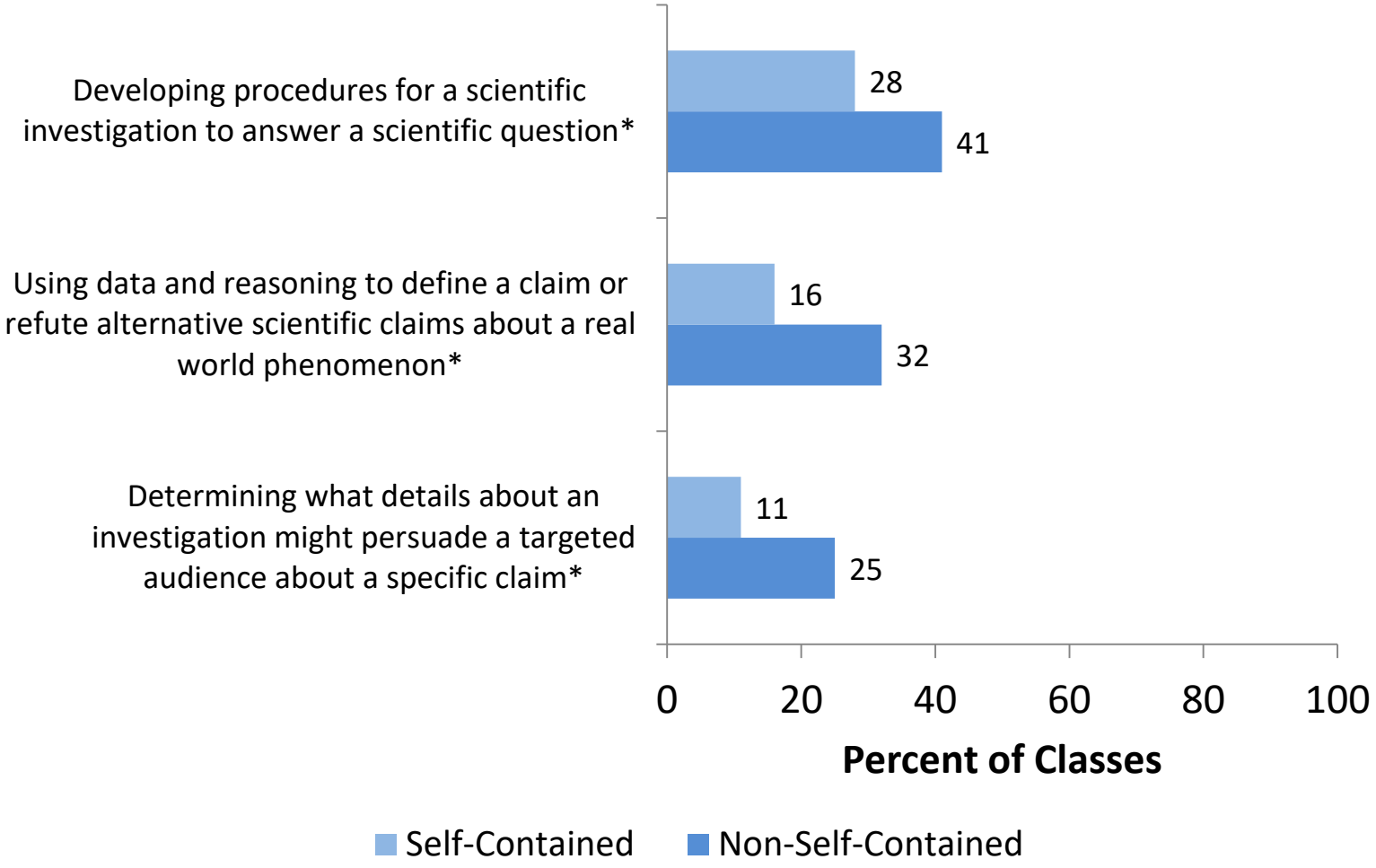
NSC science classes were more likely than SC classes to engage students in the following aspects of science practices:

- Generating scientific questions
- Organizing and/or representing data using tables, charts, or graphs
- Making and supporting claims with evidence
- Using multiple sources of evidence to develop an explanation
- Developing procedures for a scientific investigation to answer a scientific question
- Using data and reasoning to define a claim or refute alternative scientific claims about a real world phenomenon
- Determining what details about an investigation might persuade a targeted audience about a specific claim

Classes Engaging in Science Practices: Weekly



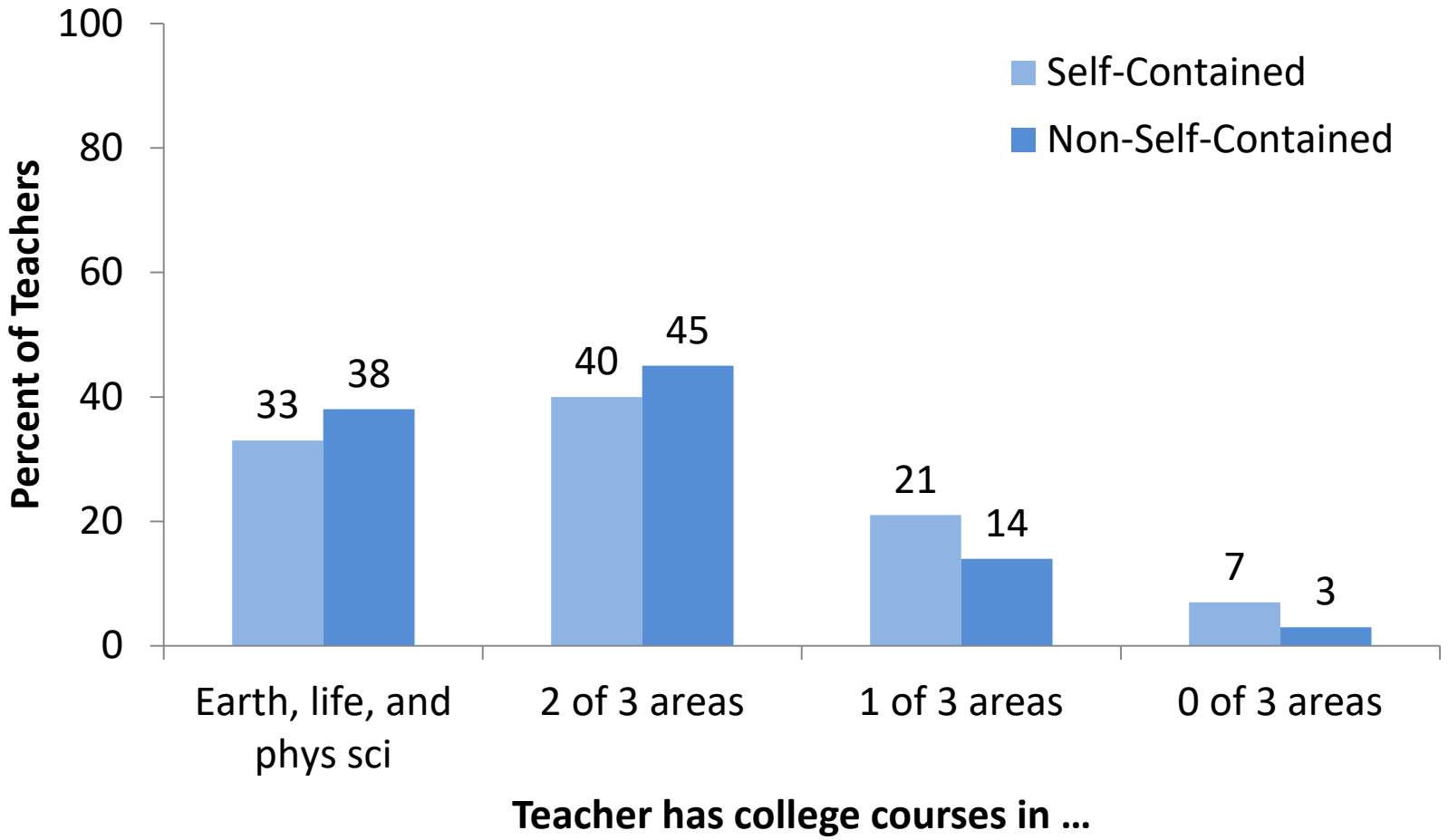
Classes Engaging in Science Practices: Weekly (cont)



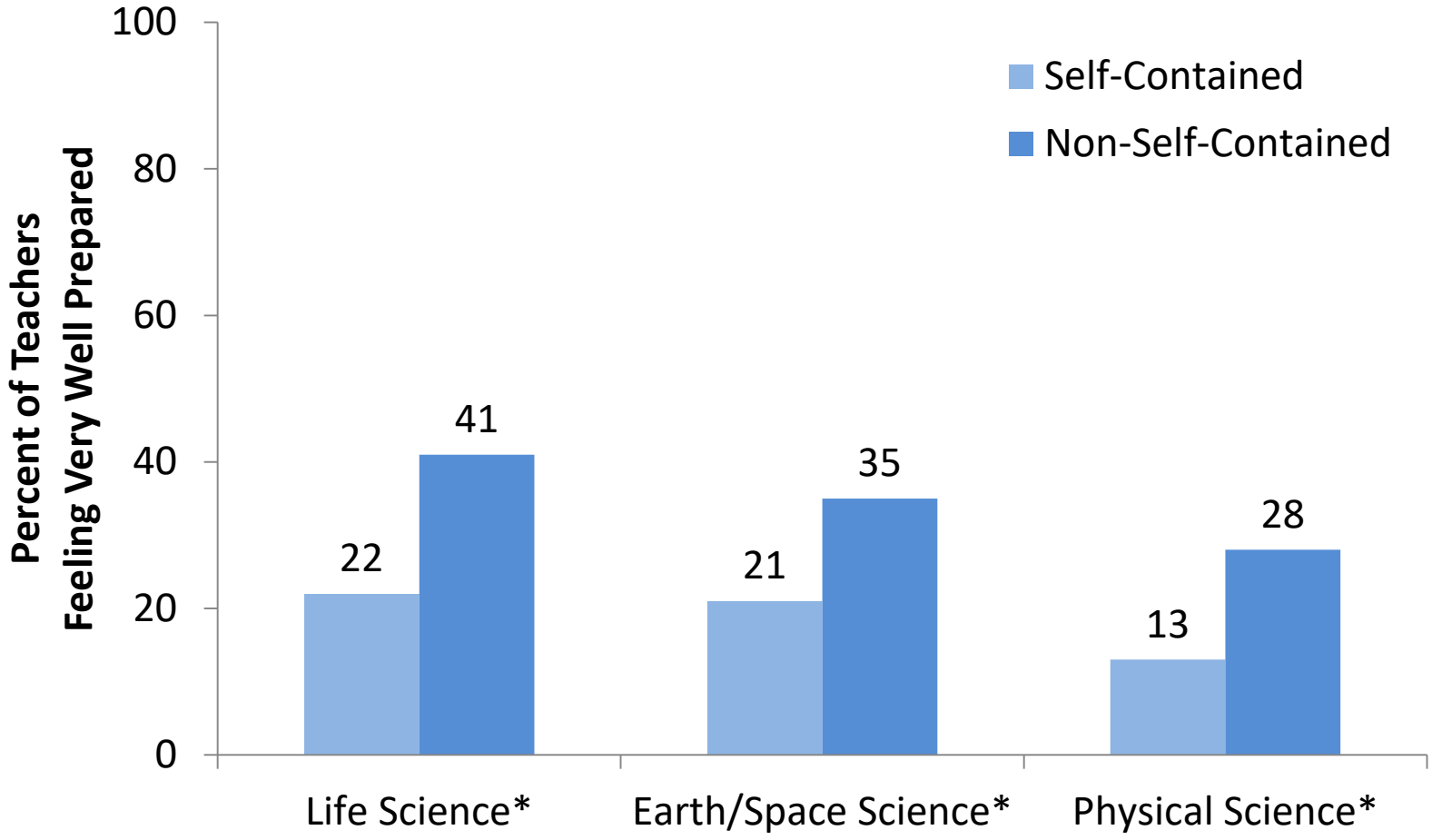
Teacher Preparation

Teachers of NSC science classes are quite similar to their SC counterparts in terms of course taking, but they are much more likely to perceive themselves as very well prepared.

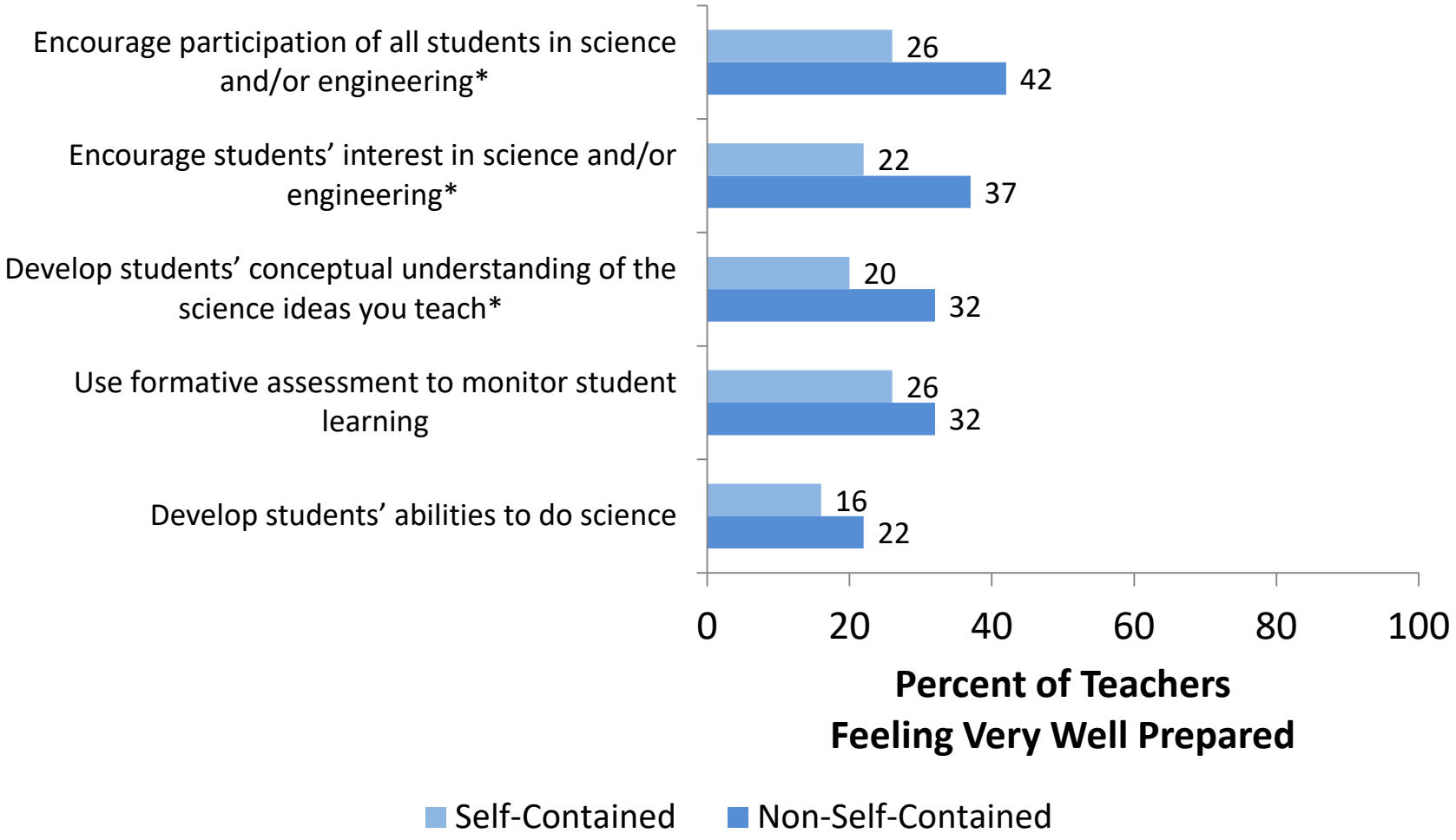
Course Taking



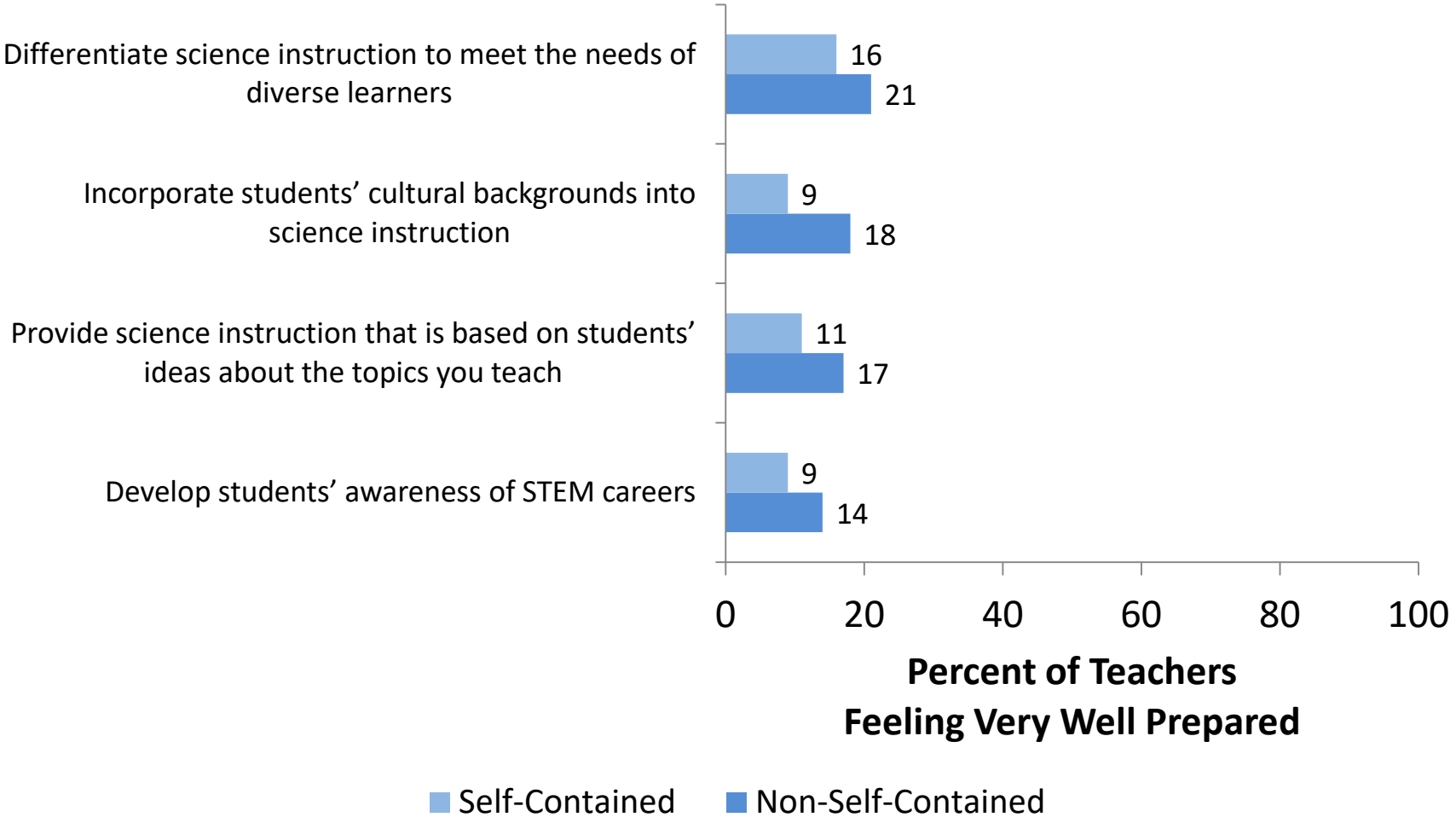
Content Preparedness



Pedagogical Preparedness



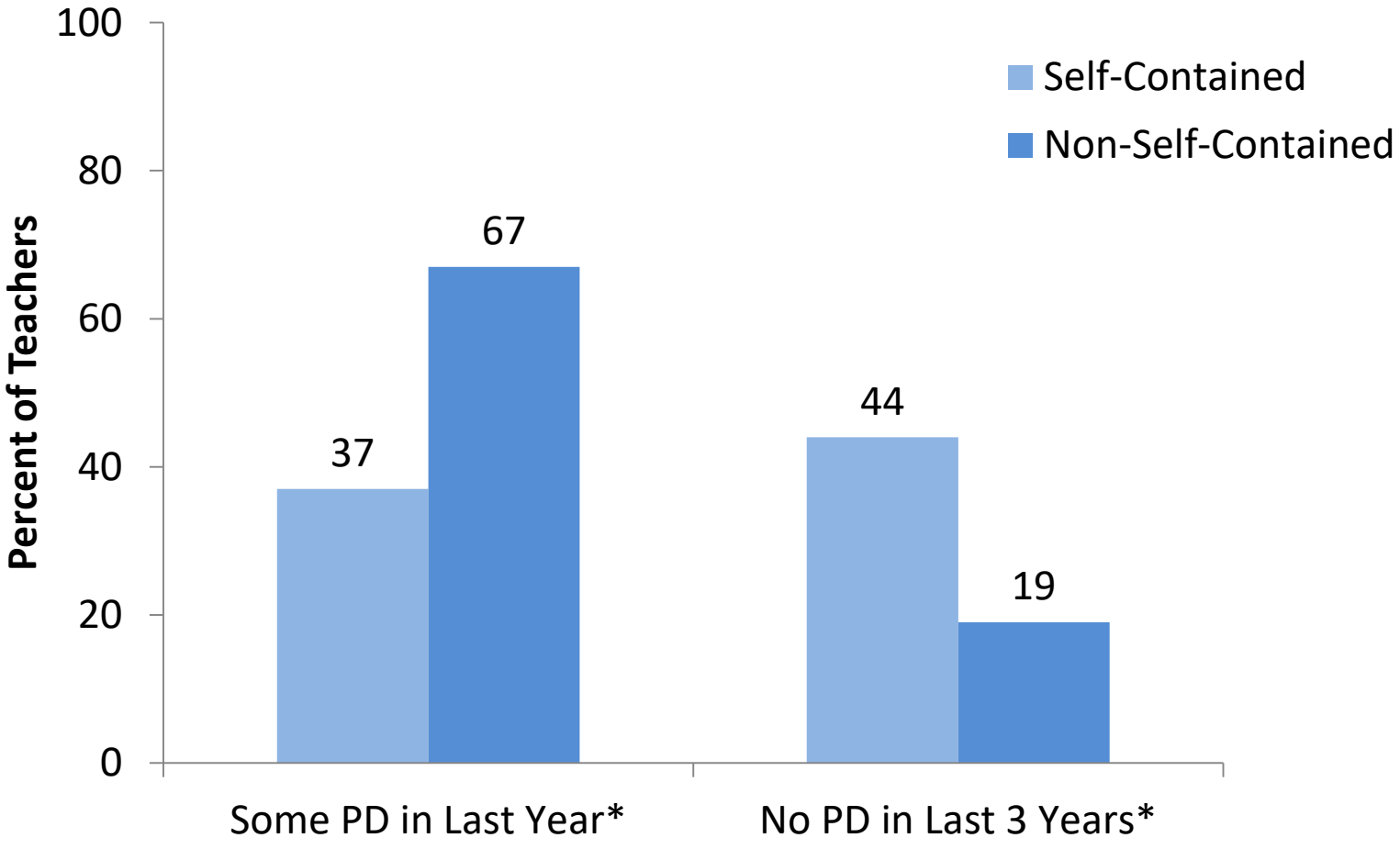
Pedagogical Preparedness (cont)



Participation in Science-Focused PD

Teachers of NSC science classes are much more likely than their SC counterparts to have participated in substantial science-focused PD.

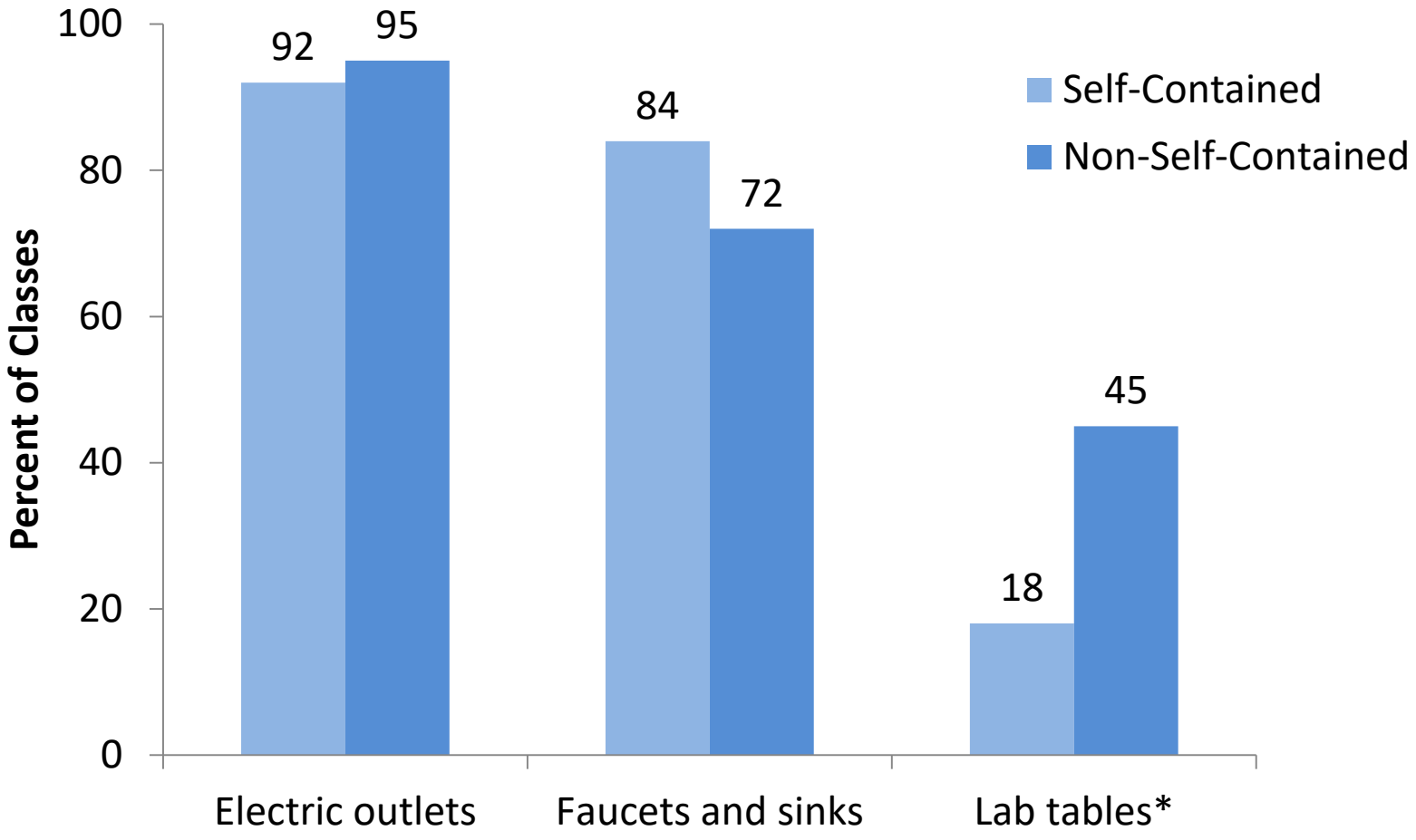
Science PD Participation



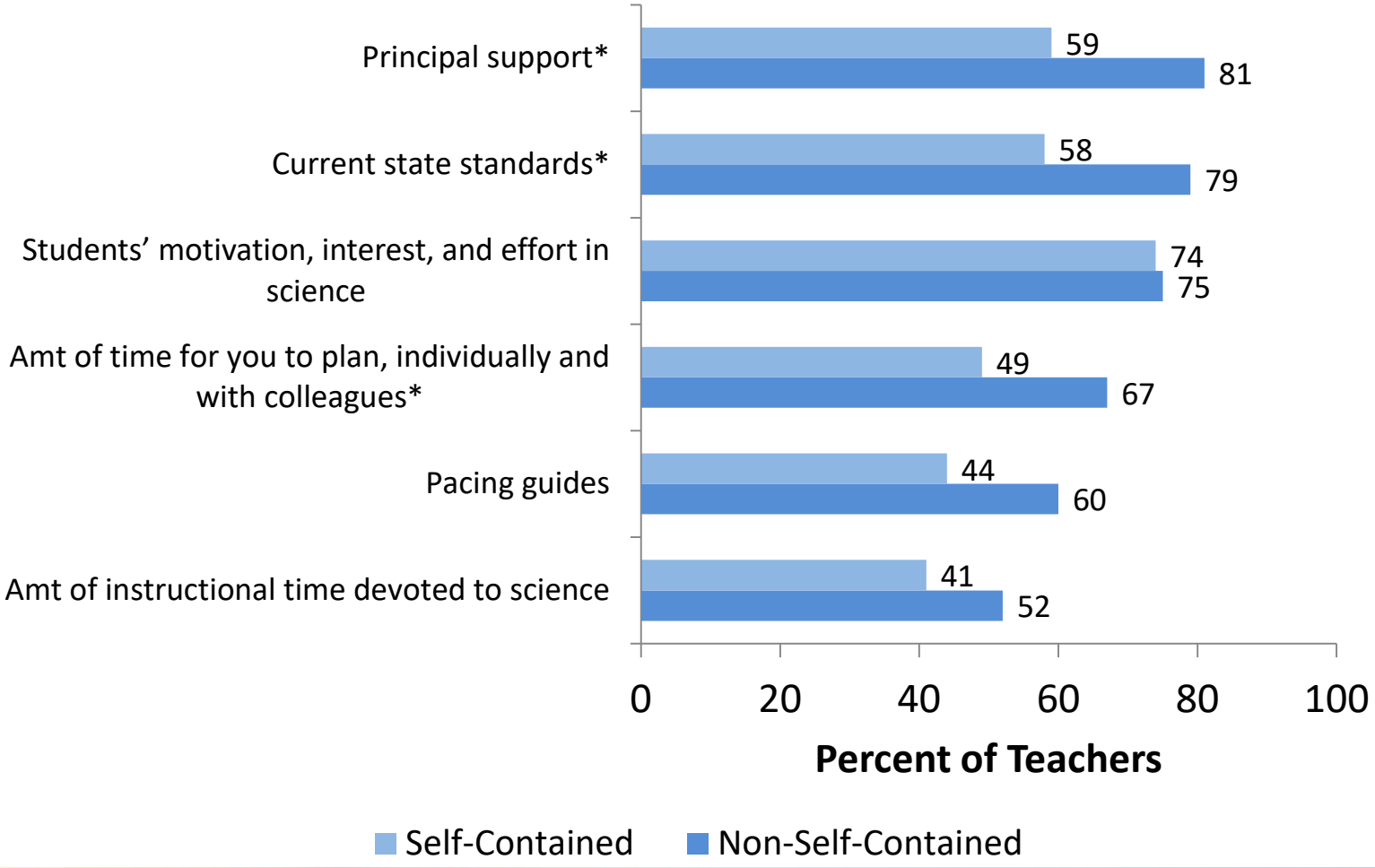
School Context

Schools that teach science in NSC settings appear to be more supportive of science on several indicators than schools that teach science in SC settings.

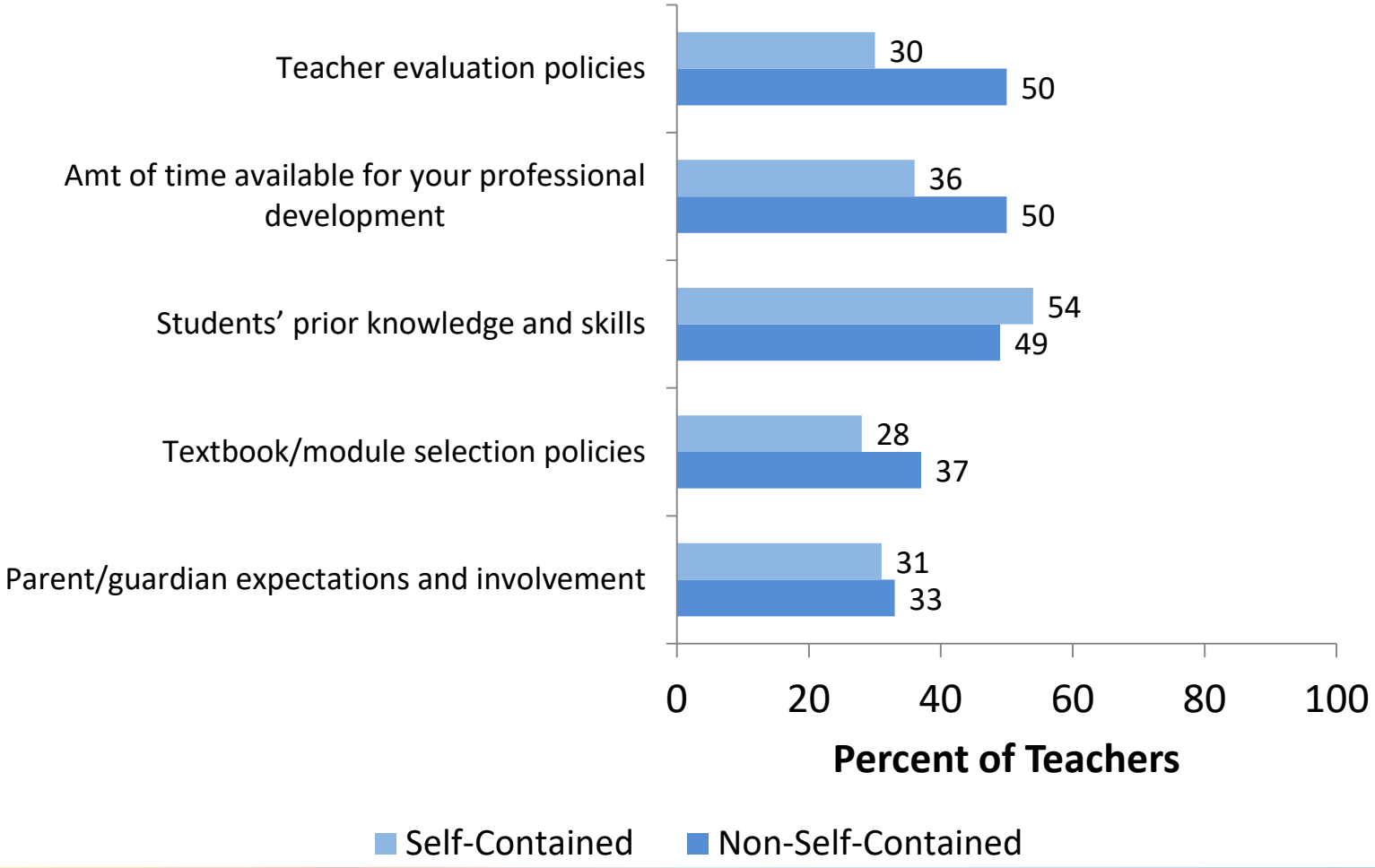
Availability of Lab Facilities



Factors Promoting Science Instruction



Factors Promoting Science Instruction (cont)



Takeaways

The data on NSC classes and teachers of those classes are very encouraging in terms of:

- Instructional time
- Instructional activities
- Teacher preparedness
- PD participation
- School context

Change is much more complex than simply shifting from SC to NSC classrooms.

The field needs a much better understanding of what happens in these classes and schools.

Reference List

Markworth, K. A., Brobst, J., Ohana, C., & Parker, R. (2016). Elementary content specialization: Models, affordances, and constraints. *International Journal of STEM Education*, 3(1), 16. https://doi.org/10.1186/s40594-016-0049-9

Smith, P. S., & Craven, L. M. (2019). *Science education in self-contained and non-self-contained elementary science classes: Comparisons of instruction and teachers in the two settings*. Horizon Research, Inc.