IES Institute of Education Sciences

Science Teachers Learning through Lesson Analysis (STeLLA®)

Intervention Report | Primary Science Topic Area

WHAT WORKS CLEARINGHOUSE™
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Large numbers of U.S. students lack proficiency in science, and students from different racial/ethnic and socioeconomic groups show disparities in science achievement. Science knowledge and skills are important for both academic and workplace success, and a variety of interventions have been developed to improve student achievement in science. These interventions include professional development programs for teachers that are designed to change teachers' content knowledge or classroom instruction in science. *Science Teachers Learning through Lesson Analysis* (*STeLLA®*) is a professional development program, developed by BSCS Science Learning, that aims to improve students' science achievement by improving teachers' science content knowledge and their abilities to (a) explain science concepts to students, (b) clearly identify to students the science concepts used in student learning activities, and (c) engage students in thinking about science.

Participating teachers learn from postsecondary science faculty to improve their knowledge of the science content areas they will teach during the school year; become familiar with *STeLLA®* lesson plans and instructional strategies; work in study groups led by *STeLLA®* professional development leaders to analyze videorecorded examples of experienced teachers implementing *STeLLA®* lesson plans and strategies; and videorecord their own classroom instruction and meet with their study group to analyze one another's videorecorded lessons.

This What Works Clearinghouse (WWC) intervention report, part of the WWC's Primary Science topic area, explores the effects of *STeLLA®* on science achievement. The WWC identified three studies of *STeLLA®*. One of these studies meets WWC standards. The evidence presented in this report is from one study of the effects of *STeLLA®* on students—including 59% White, 4% Black, 2% Asian, and 28% Hispanic students—in grades 4 and 5 in urban, suburban, and rural schools in Colorado.

What Happens When Students Participate in *STeLLA®*?

The evidence indicates that implementing *STeLLA®* has potentially positive effects on science achievement compared with another yearlong teacher professional development program.

Findings on *STeLLA®* from the one study that meets WWC standards are shown in Table 1. The table reports an effectiveness rating, an improvement index, and the number of studies and students that contributed to the findings. The effectiveness rating is based on the quality of the designs used in studies, whether the findings are favorable or unfavorable for the intervention, and the number of studies that tested the intervention. See Box 1 for more information on interpreting effectiveness ratings.

In order to help readers judge the practical importance of an intervention's effect, the WWC translates findings across studies into an "improvement index" by averaging findings that meet WWC standards within the same outcome domain. The improvement index can be interpreted as the expected change in percentile rank for an average comparison group student if that student had received the intervention. For example, an improvement index of +25 means that the expected percentile rank of the average comparison group student would increase by 25 points if the student received instruction from a teacher who had participated in *STeLLA®* instead of the professional development program provided to the comparison group teachers. A positive improvement index does not necessarily mean the estimated effect is statistically significant. Results for each individual outcome measure within domains are shown in Table 4.

The evidence presented in this report is based on available research. Findings and conclusions could change as new research becomes available.

Table 1. Summary of findings on *STeLLA®* from one study that meets WWC standards

		Study Findings	Evidence meeting WWC standards (version 4.0)	
Outcome domain	Effectiveness rating	Improvement index (percentile points)	Number of studies	Number of students
Science achievement	Potentially positive effects	+25	1	2,823

Note: For more information about outcome measures, see the study description in Table 6. The effects of *STeLLA®* are not known for other outcomes within the Primary Science topic area, including life sciences, physical sciences, and earth/space sciences.

BOX 1. HOW THE WWC REVIEWS AND DESCRIBES EVIDENCE

The WWC evaluates evidence based on the quality and results of reviewed studies. The criteria the WWC uses for evaluating evidence are defined in the Procedures and Standards Handbooks and the Review Protocols. The studies summarized in this report were reviewed under WWC Standards (version 4.0) and the Primary Science topic area protocol (version 4.0).

To determine the effectiveness rating, the WWC considers what methods each study used, the direction of the effects, and the number of studies that tested the intervention. The higher the effectiveness rating, the more certain the WWC is about the reported results and about what will happen if the same intervention is implemented again. The following key explains the relationship between effectiveness ratings and the statements used in this report:

Effectiveness Rating	Rating interpretation	Description of the evidence
Positive (or negative) effects	The intervention is ***likely*** to change an outcome	Strong evidence of a positive (or negative) effect, with no overriding contrary evidence
Potentially positive (or negative) effects	The intervention ***may*** change an outcome	Evidence of a positive (or negative) effect with no overriding contrary evidence
No discernible effects	The intervention ***may result in little to no change*** in an outcome	No affirmative evidence of effects
Mixed effects	The intervention ***has inconsistent effects*** on an outcome	Evidence includes studies in at least two of these categories: studies with positive effects, studies with negative effects, or more studies with indeterminate effects than with positive or negative effects

How is *STeLLA*® Implemented?

The following section provides details of how districts and schools can implement *STeLLA*®. This information can help educators identify the requirements for implementing *STeLLA*® and determine whether implementing this intervention would be feasible in their districts or schools. Information on *STeLLA*® presented in this section comes from the study that meets WWC standards (Taylor et al., 2017) and from correspondence with the developer.

- **Goal:** *STeLLA*® aims to improve student science achievement by improving a teacher's ability to (a) explain science concepts to students, (b) clearly identify to students the science concepts used in student learning activities, and (c) engage students in thinking about science.
- **Target population:** *STeLLA*® is offered to teachers who provide science instruction to students in kindergarten to grade 12. Training is also available for school or district personnel who wish to become *STeLLA*® professional development leaders.
- **Method of delivery:** Teachers learn from postsecondary science faculty and *STeLLA*® professional development leaders at an in-person summer institute. During the institute, teachers begin improving their science content knowledge, become familiar with *STeLLA*® lesson plans and instructional strategies, and learn to analyze videos of experienced teachers delivering model lesson plans and using the instructional strategies. During the school year, teachers videorecord themselves delivering model *STeLLA*® lesson plans and meet in study groups at their school with in-person or online guidance from their *STeLLA*® professional development leader to analyze their own and one another's videorecorded lessons.

Comparison condition: In the one study that contributes to this intervention report, students in the comparison group received science instruction from teachers who participated in a yearlong professional development program designed to improve only their science content knowledge. These teachers did not receive *STeLLA*® materials or training and support from *STeLLA*® professional development leaders.

- **Frequency and duration of service:** *STeLLA*® is a yearlong professional development program for teachers that begins with a 2-week summer institute (60 hours) followed by eight monthly grade-level study group meetings during the school year (30 hours). Personnel who wish to become *STeLLA*® professional development leaders require an additional 1 to 2 years of training. Refer to Table 2 for additional details.
- **Intervention components:** The key components of *STeLLA*® are described in Table 2. Training for personnel to become *STeLLA*® professional development leaders, which can be bundled with the teacher program, is also described in Table 2 but was not part of the study that contributes to this intervention report.

Table 2. Components of *STeLLA*®

Key component	Description
Teacher professional development	During the yearlong *STeLLA*® professional development program, teachers (a) develop science content knowledge of two topics (for example, "the earth's changing surface" and "matter and molecules in the water cycle") that they will teach in their own classrooms in the upcoming school year, (b) review and implement *STeLLA*® model lesson plans, and (c) learn instructional strategies to support student learning. The professional development program begins with a 2-week (58 to 60 hours) summer institute facilitated by postsecondary science faculty and a *STeLLA*® professional development leader. Science faculty engage teachers in short lectures, readings, activities, and discussions of science concepts. *STeLLA*® professional development leaders lead teachers through a review of content-specific background documents that describe how science lesson activities, representations of science concepts, and analogies that are typically used in science instruction might support or interfere with student learning. *STeLLA*® professional development leaders also introduce teachers to the *STeLLA*® lesson plans, teaching strategies, and process for analyzing videorecorded lessons. During the school year, teachers meet with school-based study groups of other teachers of students in the same grade and their *STeLLA*® professional development leader monthly for eight discussion sessions each lasting 3 to 4 hours to continue learning how to convey science content to students and how to implement *STeLLA*® teaching strategies in their own classrooms.
STeLLA® lesson plans	At the summer institute, participating teachers receive *STeLLA*® model lesson plans for one of the two topics. The model lesson plans are detailed guides designed to build teachers' science content knowledge and familiarity with *STeLLA*® teaching strategies. They highlight common student responses to teacher questions and suggest ways for teachers to respond to students' ideas, predictions, and questions. Teachers review these lesson plans and analyze videos of experienced teachers delivering them. In the fall, teachers practice implementing the model lesson plans in their own classrooms.
STeLLA® teaching strategies	Teachers learn instructional strategies that emphasize: • Explaining science concepts, including using accurate descriptions, analogies, visual displays or models, and other representations of scientific content that minimize student misconceptions; allowing students to practice using these representations; describing the connections between science concepts; and summarizing key elements of these concepts. • Clearly identifying to students the science concepts used in student learning activities, including establishing a learning goal with a central question or objective, selecting activities matched to the objective, sequencing science content and learning activities appropriately, and identifying how the learning activities illustrate or draw on science concepts. • Engaging students in thinking about science, including asking questions to elicit and challenge student ideas and predictions; engaging students in interpreting data, summarizing science concepts, and applying those concepts to new contexts or phenomena; and encouraging students to communicate in scientific ways. Teachers first become familiar with *STeLLA*® strategies at the summer institute by watching videos of experienced teachers using them in science lessons. Teachers later practice using the strategies in planning and delivering science instruction in their own classrooms.
Analysis of videorecorded lessons in study groups	A *STeLLA*® professional development leader works with school-based study groups to analyze videorecorded examples of science instruction and accompanying examples of student written work. Teachers discuss their own and students' understanding of the science topics covered in the lessons and learn to identify *STeLLA*® instructional strategies that the videorecorded teacher used or could have used to support student learning. At the summer institute, teachers begin learning the lesson analysis process by discussing videorecorded lessons of experienced teachers implementing *STeLLA*® model lesson plans. During the school year, teachers videorecord themselves teaching the two science topics in their own classrooms and then analyze one another's videorecorded lessons and accompanying examples of student work. In the first half of the school year, teachers analyze videos of one another delivering *STeLLA*® model lesson plans. In the second half of the school year, teachers collaborate with their study group to develop their own science lesson plans for the second science topic by incorporating *STeLLA*® teaching strategies and anticipating student misconceptions. Teachers then deliver and videorecord these lessons and meet once more to analyze one another's instruction and summarize what they have learned over the yearlong program.
STeLLA® leadership development training	Also available is a 2- to 3-year program for school or district personnel to become *STeLLA*® professional development leaders. Participants complete 1 year of leadership training before they begin providing *STeLLA*® professional development to a cohort of teachers. During the second year of the program, the leaders-in-training receive support from the *STeLLA*® developer. This component was not part of the study that contributes to this intervention report.

What Does *STeLLA*® Cost?

This preliminary list of costs is not designed to be exhaustive; rather, it provides educators an overview of the major resources needed to implement *STeLLA*®. The program costs described in Table 3 are based on the information available as of May 2020.

Table 3. Cost ingredients for *STeLLA*®

Cost ingredients	Description	Source of funding
	Implementing *STeLLA*® costs approximately $1,750 per teacher for the yearlong program. Each participating teacher attends a 2-week summer institute and eight monthly study group sessions (up to 4 hours each) during the school year. A 2-year leadership development program for school or district personnel to become *STeLLA*® professional development leaders costs approximately $10,000 per leader, but this component is not required.	Schools and districts pay BSCS Science Learning for costs of providing the *STeLLA*® summer institutes and support for participating teachers (or leaders-in-training) throughout the following school year.
	The 2-week summer institute typically takes place at a facility provided by the school district. School-year study group meetings take place at participating schools, with the professional development leader joining online or on-site depending on the availability of local *STeLLA*® professional development leaders and the agreement with BSCS Science Learning.	Schools and districts are responsible for providing the facility for the summer institute and the transportation to and from the facility. Schools and districts provide physical space for teacher professional development and classroom instruction during the school year.
	Teacher participants receive a set of grade-appropriate *STeLLA*® lesson plans for one of the two topics they will teach in the upcoming year, transcripts of program-developed videorecorded lessons and related examples of student work, a *STeLLA*® strategy guide, lesson analysis protocols, and other resources associated with *STeLLA*®. BSCS Science Learning provides teachers with online access to videorecordings made by members of their local study group. Participants training to become *STeLLA*® professional development leaders receive the same materials provided to teacher participants as well as videorecordings and transcripts from *STeLLA*® professional development sessions with teachers and additional resources specific to the leadership development program.	The fees that schools or districts pay for teacher (or leader-in-training) professional development cover the cost of program materials provided to participants. Schools and districts are responsible for the costs of videorecording participating teachers.

For More Information:

About *STeLLA*®

BSCS Science Learning, 5415 Mark Dabling Boulevard, Colorado Springs, CO 80918
Attn: Jody Bintz, Associate Director for Strategic Partnerships & Professional Learning
Email: jbintz@bscs.org Web: https://bscs.org/our-work/rd-programs/stella-science-teachers-learning-from-lesson-analysis/.
Phone: (719)-513-5550

About the cost of the intervention

Actual program costs available in consultation with the developer.

Research Summary

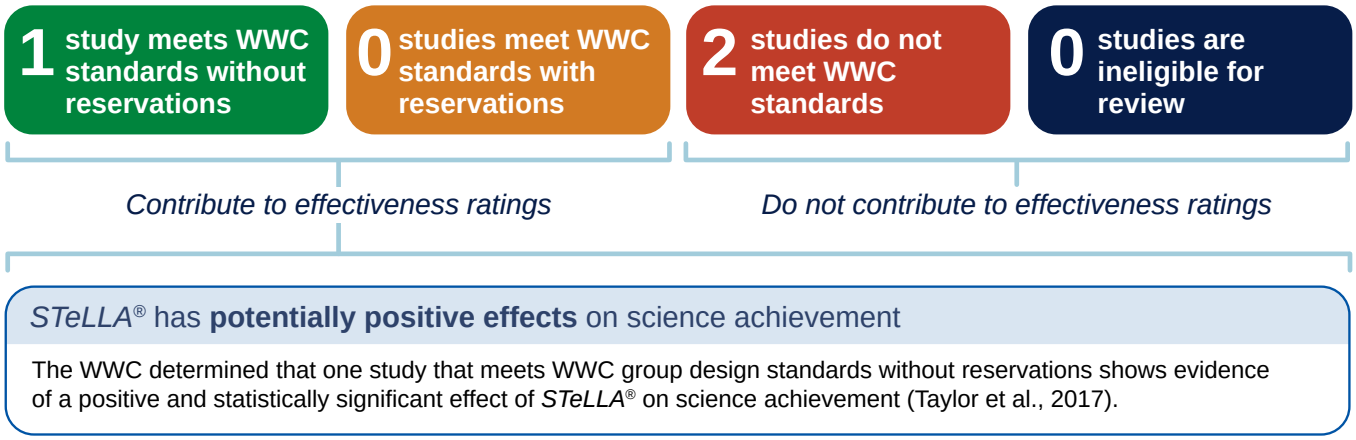
The WWC identified three studies that investigated the effectiveness of *STeLLA*® (Figure 1):

- 1 study meets WWC group design standards without reservations
- 2 studies do not meet WWC group design standards

The WWC reviews findings on the intervention's effects on eligible outcome domains from studies that meet standards, either with or without reservations. Based on this review, the WWC generates an effectiveness rating, which summarizes how the intervention impacts, or changes, a particular outcome domain.

The one study of *STeLLA*® that meets WWC group design standards reported findings on science achievement. No other findings in the study meet WWC group design standards within any outcome domain included in the Primary Science topic area.[1] Citations for the three studies reviewed for this report are listed in the References section, which begins on page 8.

Figure 1. Effectiveness ratings for *STeLLA*®



Main Findings

Table 4 shows the findings from the one *STeLLA*® study that meets WWC standards. The table includes WWC calculations of the performance of the intervention group relative to the comparison group in terms of the mean difference and effect size. The effect size is a standardized measure of the effect of an intervention on outcomes, representing the average change expected for all individuals who are given the intervention (measured in standard deviations of the outcome measure). For the mean difference and effect size values, a positive number favors the intervention group and a negative number favors the comparison group. A positive or negative improvement index does not necessarily mean the estimated effect is statistically significant.

Based on findings from the one study that meets WWC standards and includes 2,823 students, the effectiveness rating for science achievement is *potentially positive effects*.

Table 4. Findings by outcome domain from study of *STeLLA*® that meets WWC standards

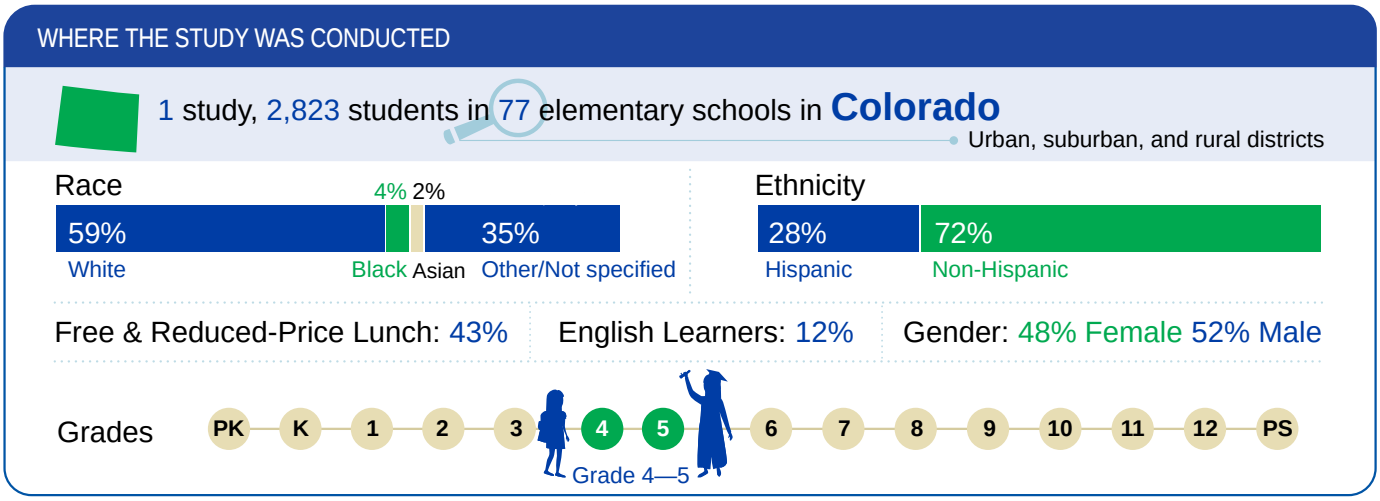
			Mean (standard deviation)		WWC calculations			
Measure (study)	Study sample	Sample size	Intervention group	Comparison group	Mean difference	Effect size	Improvement index	*p*-value
Researcher-developed science content knowledge test (Taylor et al., 2017)[a]	Students in grades 4 and 5	2,823	56.28 (9.88)	50.17 (7.71)	6.11	0.68	+25	.00
Outcome average for science achievement (Taylor et al., 2017)						0.68	+25	Statistically **significant**

Notes: Some statistics may not sum as expected due to rounding.

[a] Taylor et al. (2017) developed a science content knowledge test for this study to measure students' knowledge of science content in four areas: the earth's changing surface, energy and matter in food webs, the sun's effect on climate and seasons, and matter and molecules in the water cycle. The study is characterized as having a statistically significant positive effect on science achievement because the estimated effect is positive and statistically significant. For more information, please refer to the WWC Procedures Handbook, version 4.0, page 22.

In What Context Was *STeLLA*® Studied?

The following section provides information on the setting of the one study of *STeLLA*® that meets WWC standards, and a description of the participants in the research. This information can help educators understand the context in which the study of *STeLLA*® was conducted and determine whether the program might be suitable for their setting.



Details of Each Study that Meets WWC Standards

This section presents details for the one study of *STeLLA*® that meets WWC standards. These details include the full study reference, findings description, findings summary, and description of study characteristics. A summary of domain findings for the study is presented below, followed by a description of the study characteristics. These study-level details include contextual information about the study setting, methods, sample, intervention group, comparison group, outcomes, and implementation details. For additional information, readers should refer to the original study.

Research details for Taylor et al. (2017)

Taylor, J., Roth, K., Wilson, C. Stuhlsatz, M., & Tipton, E. (2017). The effect of an analysis-of-practice, videocase-based, teacher professional development program on elementary students' science achievement. *Journal of Research on Educational Effectiveness, 10*(2), 241-271. https://eric.ed.gov/?id=EJ1135795

Findings from Taylor et al. (2017) show evidence of a statistically significant positive effect of *STeLLA*® on science achievement (Table 5). The findings and research details summarized for this study come from two related citations, including the primary study listed above. See the References section, which begins on page 8, for a list of all related publications.

Table 5. Summary of findings from Taylor et al. (2017)

		Meets WWC Group Design Standards Without Reservations		
		Study findings		
Outcome domain	Sample size	Average effect size	Improvement index	Statistically **significant**
Science achievement	77 schools, 2,823 students	0.68	+25	Yes

Table 6. Description of study characteristics for Taylor et al. (2017)

WWC evidence rating	Meets WWC Group Design Standards Without Reservations. This is a cluster randomized controlled trial with low cluster-level attrition and low individual-level nonresponse. For more information on how the WWC assigns study ratings, please see the WWC Procedures and Standards Handbooks (version 4.0) and WWC Standards Briefs, available on the WWC website.
Setting	The study took place during science instruction in fourth- and fifth-grade classrooms in 77 public elementary schools in urban, suburban, and rural areas of Colorado. The sample consisted of traditional public schools and excluded charter and magnet schools. The study authors did not specify the number of districts.
Methods	The study assigned schools to implement one of two professional development programs, *STeLLA*® (the intervention condition) or a program focused on improving teachers' understanding of science content (the comparison condition). Two cohorts of schools participated for 1 year each, one in 2011–12 and another in 2012–13, with random assignment of each cohort occurring in the summer before the start of each school year. Study authors combined results across the two cohorts. Across the two cohorts, researchers randomly assigned a total of 84 schools (46 in the intervention group and 38 in the control group) with 3,710 students (1,979 students in the intervention group schools and 1,731 students in the control group schools). The sample loss after random assignment (attrition) was within the acceptable threshold for the review. At the school level, the overall attrition rate was 8.3% and the differential attrition rate was less than 1 percentage point. At the student level, the overall nonresponse rate was 24% and the differential nonresponse rate was 2.3 percentage points.
Study sample	The study sample included 2,823 students (1,485 in the intervention group and 1,338 in the comparison group) in fourth- and fifth-grade classrooms in the participating schools. In the participating schools, 52% of students were male, 59% of the students were White, 4% were Black, 2% were Asian, and 28% were Hispanic, on average. Twelve percent of students in the participating schools had limited English proficiency, and 43% qualified for free or reduced-price lunch, on average.
Intervention condition	Over the course of 1 school year, teachers in the intervention group participated in the *STeLLA*® professional development program, starting with a 2-week summer institute (approximately 60 hours), followed by eight once-monthly meetings during the school year in school-based study groups (approximately 30 hours). Teachers focused on two science topics that they would teach in their own classrooms in the upcoming school year: "the earth's changing surface" and "food webs" for fourth-grade teachers, and "matter and molecules in the water cycle" and "the sun's effect on climate/seasons" for fifth-grade teachers. In the summer institute, teachers alternated half-day sessions on developing science content knowledge, led by postsecondary science faculty, with half-day sessions led by *STeLLA*® professional development staff in which they became familiar with *STeLLA*® lesson plans and teaching strategies and analyzed videorecordings of experienced teachers delivering model lesson plans. During the school year, teachers videorecorded themselves delivering lesson plans (program-provided or developed with their study group) and participated in monthly 3- to 4-hour school-based study group sessions facilitated by a *STeLLA*® professional development leader to analyze one another's instruction.
Comparison condition	Teachers in the comparison group participated in a 1-year professional development program focused on developing science content knowledge in the same two topic areas as the intervention group: "the earth's changing surface" and "food webs" for fourth-grade teachers and "matter and molecules in the water cycle" and "the sun's effect on climate/seasons" for fifth-grade teachers. The program began with a 2-week summer institute (approximately 60 hours), followed by five 6-hour meetings during the school year (30 hours total). Postsecondary science faculty led both the summer institute and school-year sessions. In contrast to teachers in the intervention group, teachers in the comparison group did not receive training or support from *STeLLA*® professional development leaders. Teachers in the comparison group also did not receive *STeLLA*® lesson plans, learn about instructional strategies, nor participate in analysis of videorecorded science instruction.
Outcomes and measurement	Study authors reported findings on a science content knowledge test within the science achievement domain that they developed using a combination of new items and items from extant tests including the National Assessment of Educational Progress, Trends in International Mathematics and Science Study, and assessments developed by other researchers and funded by National Science Foundation grants (see Taylor et al., 2017, pp. 256, 266). The researcher-developed test included multiple-choice items covering four topics (the earth's changing surface, energy and matter in food webs, the sun's effect on climate and seasons, and matter and molecules in the water cycle). Study findings were based on students' spring scores, which covered two of the four topics. The test was administered 2 weeks after the teacher completed instruction on the topics. The study authors used statistical methods to generate a single measure of science content knowledge for each student. This researcher-developed measure had a reliability of 0.83, which meets the WWC's outcome requirements.[2]
Additional implementation details	An external evaluator conducted an implementation study and gave similar ratings to the professional development provided to the intervention and comparison groups. The ratings were for the following indicators: effectiveness of the professional development provider, pacing of the sessions, teacher engagement, and collaboration among teachers. Observers rated the *STeLLA*® intervention group as spending more time on pedagogical issues and lesson analysis, and less time on science content, than the comparison group.

References

Study that meets WWC group design standards

Taylor, J., Roth, K., Wilson, C., Stuhlsatz, M., & Tipton, E. (2017). The effect of an analysis-of-practice, videocase-based, teacher professional development program on elementary students' science achievement. *Journal of Research on Educational Effectiveness, 10*(2), 241–271. https://eric.ed.gov/?id=EJ1135795

Additional source:

Roth, K. J., Wilson, C. D., Taylor, J. A., Stuhlsatz, M. A. M., & Hvidsten, C. (2019). Comparing the effects of analysis-of-practice and content-based professional development on teacher and student outcomes in science. *American Educational Research Journal, 56*(4), 1217–1253. https://eric.ed.gov/?id=EJ1222472

Studies that meet WWC group design standards with reservations

None.

Studies that do not meet WWC group design standards

Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I. Z. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal of Research in Science Teaching, 48*(2), 117–148. https://doi.org/10.1002/tea.20408 The study does not meet WWC group design standards because the measures of effectiveness cannot be attributed solely to the intervention.

Wilson, C. D., Stuhlsatz, M., Hvidsten, C., & Gardner, A. (2018). Analysis of practice and teacher PCK: Inferences from professional development research. In S. Uzzo, S. Browne Graves, E. Shay, M. Harford, R. Thompson (Eds.), *Pedagogical content knowledge in STEM: Research to practice* (pp. 3–16). Springer International. https://rd.springer.com/chapter/10.1007/978-3-319-97475-0_1 The study does not meet WWC group design standards because it does not establish the reliability of the eligible outcomes.

Additional source:

Wilson, C. D., Stuhlsatz, M., Hvidsten, C., & Stennett, B. (2017, April). *Examining the impact of lesson-analysis based teacher education and professional development across methods courses, student teaching, and induction* [Conference session]. Annual International Conference of the National Association for Research in Science Teaching, San Antonio, TX, United States. https://cadrek12.org/sites/default/files/NARST%20ViSTA%202017.pdf

Studies that are ineligible for review using the Primary Science review protocol

None.

Endnotes

[1] The effects of *STeLLA*® are not known for other outcome domains within the Primary Science topic area, including life sciences, physical sciences, and earth/space sciences.

[2] The authors used Rasch common person equating to estimate each student's science content knowledge score on an equal interval scale and reported the measure's Rasch person reliability. The authors compared Rasch common person equating to item-equating processes used in tests like the National Assessment of Educational Progress, in which different students respond to different test items but all students receive an estimated score on a common scale. See works cited in Taylor et al. (2017): Bond, T. G., & Fox, C. M. (2007). *Applying the Rasch model fundamental measurement in the human sciences* (2nd ed.). Lawrence Erlbaum; and Boone, W. J., & Scantelbury, K. (2006). The role of Rasch analysis when conducting science education research utilizing multiple-choice tests. *Science Education, 90*(2), 551–569.

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