StarrMatica's Virtual Science Coach Research Basis

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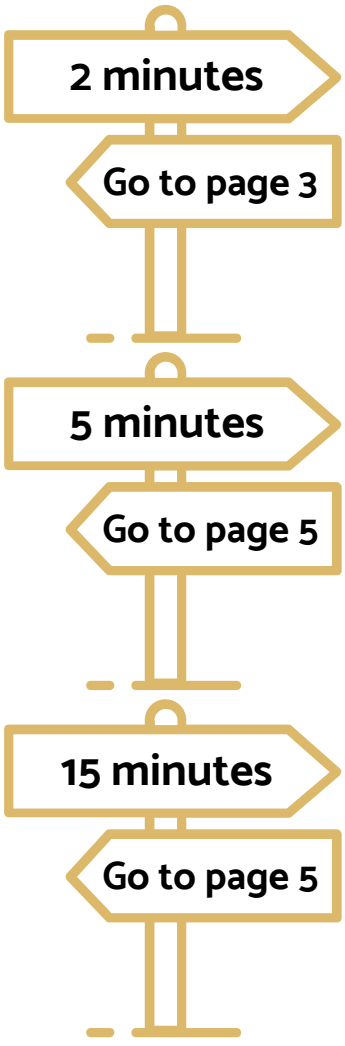
StarrMatica

StarrMatica's Virtual Science Coach Research Basis

WELCOME

Thank you for investing a few minutes of your valuable time to learn how to give every child in your school the opportunity for a bright future in STEM! While we feel all of the information contained in this document is important and compelling, as educators ourselves, we want to help you make the best use of your time. We invite you to choose the level of detail you can commit to reviewing now and to download this entire document for your future reference.



Review a two page summary of our research basis and proven effectiveness.

Read a letter from our CEO followed by margin notes summarizing the research findings.

Read a letter from our CEO followed by the full whitepaper describing our research basis in both the literature and though our externally deployed research study.

Research Summary

LITERATURE REVIEW: THE PROBLEM

77% of our workforce requires STEM skills. But only 30% of our college students choose STEM careers. This creates a STEM workforce gap that is growing larger.

By 8th grade, almost half of students are no longer interested in STEM – and of those still interested, there are half as many girls.

Research shows that the most effective way to solve this issue is to spark an interest in STEM in elementary school. It is even more effective than encouraging high school students to take more advanced courses.

Teachers are the most important factors in the quality of a student's science education. Yet many elementary teachers have reported feeling unprepared and uncomfortable teaching science, and research shows they often lack adequate content knowledge.

The degree to which students report they "like science" is correlated with a teacher's amount of content knowledge.

New curriculum materials do not solve the issue. Teachers can use high-quality content, yet not teach those materials in a way that will move student thinking forward.

LITERATURE REVIEW: THE SOLUTION

Professional development is essential to improve teacher practices. Several studies suggest that **the duration of professional development is related to the amount of teacher change it effects.**

Professional development should be focused on pedagogy. **High-performance teaching is linked with content knowledge.** In fact, "the greatest single contributor to explaining student progress" is a teacher's pedagogical content knowledge.

Research shows that **teachers' questions are essential to an effective science** classroom. In fact, Wilen and Hogg suggest that inquiry teaching is "crucially dependent upon the teacher's ability to ask questions that are congruent to the levels of thinking desired."

This foundational science teaching knowledge - knowledge of standards, productive questioning, discussion facilitation, and science content knowledge - is required to significantly improve student achievement.

Research Summary

RESEARCH RESULTS

After six months of using the Virtual Science Coach:

Teachers had a statistically significant difference between pre- and posttest scores measuring their **knowledge of the NGSS.** The difference was large in magnitude and translated to an increase from the 50th percentile to the 95th - 99th percentile.

Teacher's **questioning** quiz scores were significantly higher, and the difference was large in magnitude after completion of the questioning lessons in the VSC.

Analysis of pre- and post quizzes measuring **science content knowledge** shows that teachers were able to significantly increase their scores, and this difference was large in magnitude.

The teachers had statistically significant differences between pre- and posttest scores measuring their **science teaching self-efficacy**. The difference was large in magnitude and translated to an increase from the 50th percentile to the 81st percentile.

THE VIRTUAL SCIENCE COACH

StarrMatica is reinventing professional development with “bite sized” coaching that empowers busy classroom teachers to become rock star science educators.

The Virtual Science Coach’s online sessions – each 20 minutes or less – intently focus on research-based teaching strategies proven to raise student achievement in science. While lesson plans describe WHAT to teach, our method shows teachers HOW to teach science. Easy in-district implementation ensures all current and future teachers have foundational science teaching knowledge that is proven effective.

The Virtual Science Coach was designed by university professors and experienced classroom educators based on research to ensure that no matter how much time is devoted to science or what lesson materials are available, teachers understand how spark an interest in STEM.

A Letter from our CEO

Dear Colleague in Education,

I founded StarrMatica in 2005 to improve the lives of more students than I could within the walls of my classroom. I believe we owe our students nothing less than helping them to reach their full potential. Research shows that elementary teachers have the greatest impact on a student's future in STEM, so that is why StarrMatica is focused on helping all elementary teachers become rock star science educators.

As a former fourth grade teacher, I know that professional development time and resources are always limited. Teachers are pulled in a million different directions with important to-do lists that never quite get completed. That is why it is so important that we ensure the professional development we provide for our teachers is proven effective — that it is worth their time and effort because of the guaranteed positive impact it will have on their teaching practice and the lives of their students.

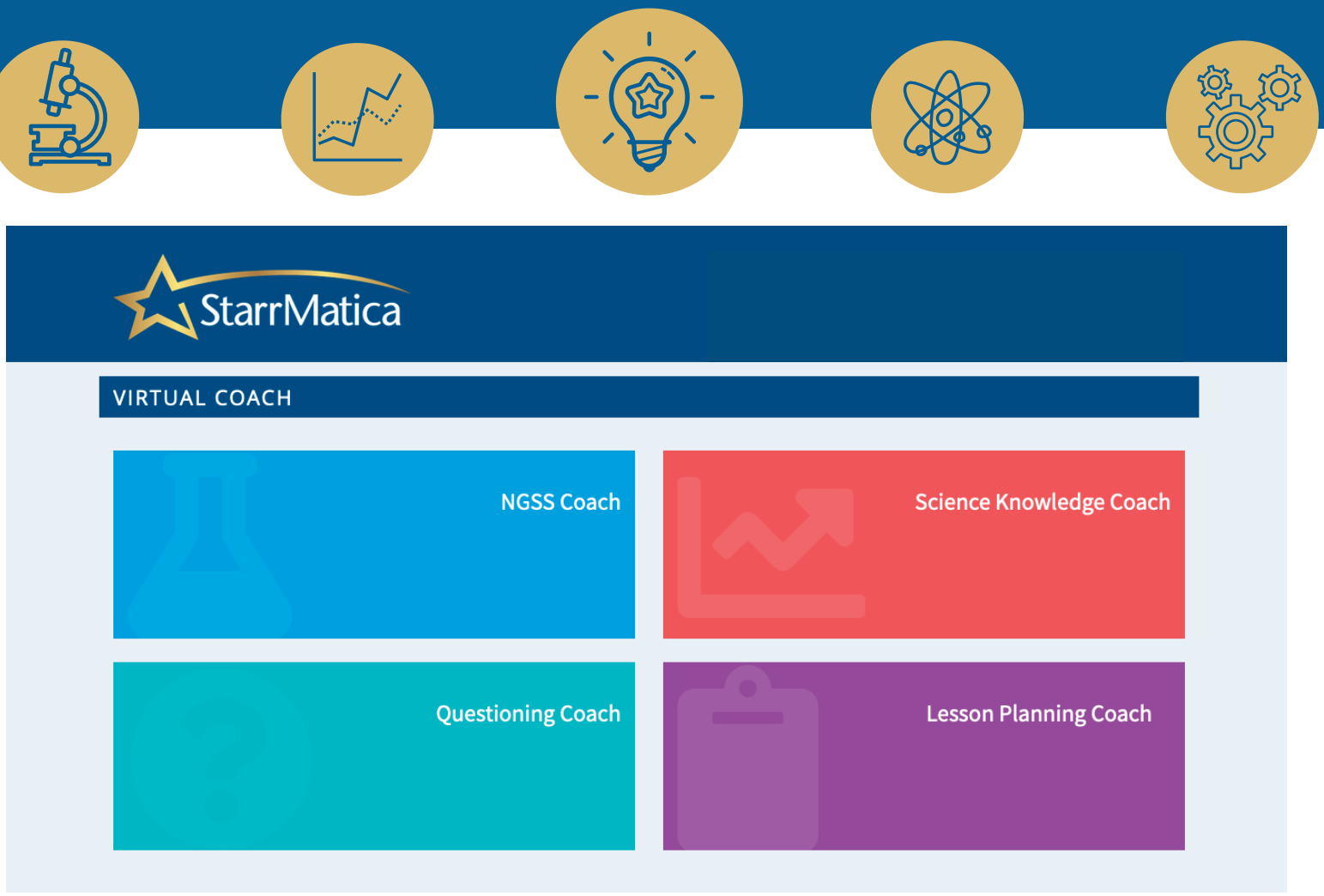
Since the release of the NGSS, school districts we serve have shared their challenges and struggles with improving their science instruction. Out of a desire to help our colleagues, StarrMatica brought together seasoned university professors and dynamic classroom educators to create the Virtual Science Coach Professional Development Partner (VSC).

The VSC was designed based on a broad and deep review of scientific literature that revealed the key skills teachers need to acquire to become highly effective at teaching science. We built the VSC around that set of skills to lay a foundation for high quality science instruction, regardless of a teacher's curriculum materials. Then we deployed the VSC to teachers around the country and gathered data on its effectiveness though a research study conducted by the University of Nebraska-Lincoln. The impact on science instruction was astounding. Teachers had statistically significant improvement in their questioning skills, NGSS knowledge, science content knowledge, and belief in their ability to teach science.

This document was created to share those research results with you. It describes StarrMatica's research basis — both in the literature and through our external research study. If you are ready to dive deep in the research weeds, I invite you to read the entire narrative. The information is compelling and will provide you with an understanding of the solid research foundation upon which the VSC was constructed. If you don't have time for a thorough reading at this moment, I invite you to explore the margin notes embedded within the document which summarize the main ideas for you. Thank you for allowing us to share our knowledge with you!

Emily Starr
CEO, StarrMatica

StarrMatica's Virtual Science Coach Research Basis



StarrMatica's Virtual Science Coach was funded by two highly competitive Small Business Innovation Research Grants (SBIR) awarded by the National Institute of Food and Agriculture. Development collaborators included Emily Starr of StarrMatica Learning Systems; Dr. Dana Atwood-Blaine, Jacobson Elementary STEM Fellow and Associate Professor of Elementary Science Methods at the University of Northern Iowa; Aaron Spurr, Earth Science expert and professor at the University of Northern Iowa; Karen Breitbach, Physical Science expert and professor at the University of Northern Iowa; Michael Vitalini, Life Science expert and professor at St. Ambrose University; and Qi Learning Research Group; along with award winning authors, video production companies, editors, graphic designers, and voice talents.

The following narrative summarizes the literature that forms the research-basis for StarrMatica's Virtual Science Coach. This discussion is followed by a summary of the results of our externally deployed research study.

Teachers are the most important factors in the quality of a student's STEM education. Research indicates that students achieve more when instructed by a highly effective teacher (Margot & Kettler, 2019; Chetty, Friedman, & Rockoff, 2011; Effective teachers, 2003; Hanushek, Kain, O'Brien, & Rivkin, 2005; Kaplan & Owings, 2002)

Teachers are the most important factors in the quality of a student's STEM education.

A highly effective teacher in elementary school is essential to a student's future success in STEM fields. Research suggests that to ensure eventual success in STEM careers, we must interest students in STEM at an early age (Baine, 2008; DeJarnette, 2012; Johnson, 1987; Maltese & Tai, 2010; Murphy & Mancini-Samuelson, 2012; Weinburgh, 1995). Sparking students' interest in STEM in elementary school is more effective in creating eventual STEM career paths than encouraging high school students to take more advanced courses (Maltese & Tai, 2010). **Yet many elementary teachers have reported feeling unprepared and uncomfortable teaching STEM, and research shows they often lack adequate content knowledge** (Hibpshman, 2007; Lantz, 2009; Moore et al., 2014). Only 50% of elementary teachers who were surveyed felt that they were well prepared to teach science (Banilower et al., 2013).

To ensure eventual success in STEM careers, we must interest students in STEM at an early age.

A teacher who lacks adequate STEM content knowledge may not be able to make the connection for her students between science and future careers. This connection is essential because research shows that **by eighth grade, almost half of students are no longer interested in STEM or believe it is irrelevant to their education and future plans** (Murphy, 2011). Those who still have interest in STEM "often enter postsecondary programs without a clear understanding of the field, its practice, or its impact on society" (Gomez, Oakes, & Leone, 2006). **Research shows that targeting students' interests and motivation before the eighth grade can significantly facilitate their career intentions and persistence in STEM fields** (Maltese & Tai, 2010; PCAST, 2012; Tai, Liu, Maltese, & Fan, 2006).

Because teachers are so focused on reading and math, they never find the extra time that it takes to teach — or even prepare to teach — science.

Elementary teachers face a plethora of issues when it comes to teaching science. As generalists, elementary teachers must teach every subject — unlike their middle school and high school counterparts. This results in a time crunch in which teachers must prioritize their limited planning and instructional time. English Language Arts and Mathematics receive the most time and attention because they are the focus of today's standardized tests, to which teachers and schools are held accountable (Allen, 2006; Appleton, 2007; Center on Educational Policy, 2008; Crocco & Costigan, 2007). **In fact, science is one of the first things to be sacrificed in a typical elementary school day because teachers are so busy with the other subjects that they never find the extra time that it takes to teach — or even prepare to teach — science** (Allen, 2006).

Adding to the issue of a lack of time for science is the fact that elementary teachers tend to lack an adequate content and pedagogical background in science, and consequently, they have low confidence in teaching science (Rice, 2005; Cochran & Jones, 1998; Fulp, 2002; Tilgner, 1990). Elementary teachers may avoid teaching science, or only teach the topics with which they are most comfortable or simply rely on "activities that work" (i.e., that run smoothly and yield expected results) rather than engaging in meaningful, coherent, inquiry-oriented science teaching (Appleton, 2007). These research results are troubling, given that the degree to which students report they “like science” is correlated with a teacher’s amount of content knowledge, as reflected by the number of science courses taken (Druva and Anderson, 1983).

Elementary teachers tend to lack content & pedagogical background in science, which results in low confidence in teaching science.

The Next Generation Science Standards (NGSS) release has magnified and compounded these already prevalent issues. The NGSS are written in the form of student performance expectations, and they integrate three dimensions of learning — Disciplinary Core Ideas, Science and Engineering Practices, and Cross Cutting Concepts (The NGSS, 2013).This is a significant change from previous science standards that were statements of knowledge. Research has specifically documented the vast gap between the way science is currently taught and the best practices the NGSS promotes (Roth, 2014). **Implementing the NGSS requires large shifts in the way science is taught and places heavy demands on time** (Dougherty, 2015). Elementary teachers don’t have the time, the content resources, the science background, or the pedagogical knowledge — nor the curriculum-development experience — to make a transformation of this magnitude on their own [SLS3] (Rice, 2005; Birman, Desimone, Porter, & Garet, 2000; Wilson, 2013; Fulp, 2002; Tilgner, 1990).

The degree to which students report they “like science” is correlated with a teacher’s amount of content knowledge.

Teachers can’t simply align their current curriculum materials to the NGSS and continue teaching as they have in the past. Based on this school curriculum environment, teachers must, by default, supplement textbook core curriculum to meet the NGSS. This is an enormous task, given the complexities of the NGSS. It is also unrealistic to expect teachers with different levels of experience to achieve this goal effectively without adequate support. Teachers are searching multiple sources for supplementary materials that they must then self-evaluate (National Academies of Sciences, Engineering, and Medicine Committee et al., 2015). The problem is that many elementary teachers don’t have the content knowledge or the curriculum knowledge to successfully evaluate the materials they find (Howley, A. & Howley, C., 2005). **These factors can result in the use of low-quality and technically inaccurate science supplementary materials** (Metzger et al. 2010).

Elementary teachers don’t have the time, the content resources, the science background or pedagogical knowledge — nor the curriculum-development experience — to make the NGSS shift on their own.

However, improving access to high-quality NGSS-aligned materials is not the sole answer to improved elementary science instruction. According to a report by the National Academies of Sciences, “teachers in elementary classes using commercially published materials frequently supplement them with other materials, and do not always use the commercially published materials as designed.”

StarrMatica’s external Virtual Science Coach research study supports this reality. Even when teachers were given fully aligned NGSS curriculum materials, they were still not instructing in a way that would move student thinking forward as measured by the Science Teaching Inquiry Rubric. **To instruct in the way the NGSS requires, teachers must improve both their content knowledge as well as their pedagogical content knowledge** (National Academies of Sciences, Engineering, and Medicine Committee et al., 2015).

One way to improve teacher performance is through professional development (PD). **Research suggests that extensive and effective PD is required to successfully implement the NGSS** (Birman, Desimone, Porter, & Garet, 2000; Wilson, 2013); however, rural schools have more limited PD opportunities because of financial and geographic limitations (Hammer Cahape et al., 2005).

Also concerning is the higher than average teacher turnover rate of 40-50% experienced in rural schools (Harmon, 2001; Ingersoll, 2001; NCTAF, 2003). The pandemic has put a spotlight on the teacher attrition and mobility rates nation wide. This revolving door for teachers makes it difficult to implement system-wide professional development, establish a coordinated curriculum, and provide continuity for students (Ingersoll, 2001; Jimerson, 2003). The Virtual Science Coach's (VSC) online delivery and in-district implementation provides a system for standardizing elementary science instructional expectations throughout a district for both current and future teachers.

New curriculum materials do not solve the issue. Teachers use high-quality content, and yet do not teach those materials in a way that will move student thinking forward. Teachers must improve their pedagogy.

Professional development is required to successfully implement the Next Generation Science Standards.

High teacher mobility & attrition rates make it difficult to implement system-wide professional development, establish instructional expectations & provide continuity for students.

Research has shown that teacher professional development is necessary for many reasons: 1) Teachers require professional development to implement curricula in reform-oriented ways, as the NGSS requires. (Birman et al., 2007); 2) Professional development is essential for teachers to implement instructional changes with fidelity (Taylor, Van Scotter, & Coulson, 2007; Cohen & Hill, 2002); 3) **Marked growth in teaching practice is associated with effective PD** (Phillips, Desimone, & Smith, 2011); 4) Effective PD gives teachers the tools for developing higher order and critical thinking in students (Hochberg & Desimone, 2010).

One-time professional workshops or classes do not improve teacher practices long term.

Commonly used one-time professional development workshops do not improve teacher practices (Yoon, 2007). **In fact, several studies suggest that the duration of professional development is related to the amount of teacher change it effects** (Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgway, & Bond, 1998). Specifically, coaching over time has been shown to be an effective way to provide elementary teachers with immediate and individualized assistance that results in improved teacher pedagogy (Knight, 2004; Kohler, Crilley, Shearer, & Good, 1997; Neufeld & Roper, 2003; Showers, B, & Showers, J., 1996).This type of person-to-person coaching isn't feasible in most districts because of time and cost limitations. The Virtual Science Coach (VSC) is designed to apply the known effective strategy of coaching to a digital environment by first instructing teachers on the skills needed to improve their pedagogy and then coaching them throughout the year with materials for every K-5 NGSS Performance Expectation to help them apply what they have learned to every science lesson they teach.

VSC is designed to apply the effective strategy of coaching to a digital environment by first instructing teachers on the skills needed to improve their pedagogy & then coaching them throughout the year to apply what they have learned to every science lesson they teach.

There are three research-based characteristics incorporates that professional development must employ to be effective: It is focused on specific curriculum content, it is related to academic standards, and it gives teachers opportunities to apply their knowledge (Garet et al., 2001). Since teaching elementary science effectively is a complex task, and the goal of improving elementary science instruction is quite broad, the VSC is focused on "the greatest single contributor to explaining student progress": pedagogical content knowledge (PCK) (Baumert et al., 2010). Gess-Newsome defined PCK as "the knowledge of, rationale behind, planning for, and act of teaching a specific piece of subject matter, in a specific context, to support student learning of the material" (Gess-Newsome, 2015). To improve science instruction, teachers must not only improve their content knowledge, but also their PCK so they can help students to understand the content (Halim & Meerah, 2002).

The VSC improves a teacher's PCK by increasing a teacher's science content knowledge and improving a teacher's questioning skills so that he/she can best use that knowledge to improve student understanding. The decision to focus on improving science content knowledge was made based on the research that **high-performance teaching is linked with content knowledge** (Howley, A. & Howley, C., 2005; Ratcliffe & Millar, 2009). McDiarmid et al. (1989) concluded that **a teachers' content knowledge largely influences the quality of their teaching**. He reported that "teachers' capacity to pose questions, select tasks, evaluate their pupils' understanding, and to make curricular decisions all depend on how they themselves understand the subject matter." Teachers with adequate science content knowledge are more likely to use inquiry-based instruction, which is a best practice in science education (Kolbe & Jorgensen, 2018). Garet, et al. (2001) describes the "profound importance of subject-matter focus in designing high-quality professional development."

"The greatest single contributor to explaining student progress" is a teacher's pedagogical content knowledge.

Professional development that is focused on content knowledge and a deepening of teachers' content skills is particularly helpful when the PD is seeking to improve students' conceptual understanding (Cohen & Hill, 1998; National Research Council, 1996; Kennedy, 1998). Professional development focused on improving teacher science content knowledge has been shown to also improve self-efficacy (Lumpe et al., 2012). Teachers with high levels of self-efficacy tend to use highly effective teaching strategies and are less likely to burn out (Woolfolk, Hoy & Davis, 2006; Zee & Kooman, 2016). Teacher self-efficacy is also positively related to student achievement (Lumpe et al., 2012; Zee and Koomen, 2016).

The VSC improves a teacher's PCK by increasing a teacher's science content knowledge and improving a teacher's questioning skills so that he/she can best use that knowledge to improve student understanding.

A focus on questioning was chosen in light of the research that **teachers' questions are essential to an effective science classroom** (Gall, 1970; Orlich and Migaki, 1981; Penick, Crow, and Bonnstetter, 1996). In fact, Wilen and Hogg (1976) suggest that inquiry teaching is "crucially dependent upon the teacher's ability to ask questions that are congruent to the levels of thinking desired." According to the National Research Council (2000), inquiry teaching is defined by a teacher's questioning skills. *Yet, questioning is one of the weakest areas of science instruction.* Teaching inquiry-based science, in the way the NGSS requires, is not possible without effective questioning. **Even when a lesson is otherwise well-designed, fewer than one in five lessons incorporate questioning that is likely to move student understanding forward** (Weiss et al., 2003).

Questioning is one of the weakest areas of science instruction for a majority of teachers, yet science instruction that will move student understanding forward is not possible without effective questioning.

Bowes and Banilower (2004) found that less than half of lessons from teachers who had attended years of professional development (not focused on improving questioning) were adequate in the areas of questioning and sense-making opportunities. **Teachers who are specifically trained to ask high-quality questions show significant improvement in constructing and using such questions in the classroom** (Angletti, 1991).

Content knowledge and questioning techniques are linked in their ability to improve science instruction. **Druva and Anderson (1983) found that teachers with greater content knowledge and more teaching experience were more likely to ask cognitively based (higher level) questions and more likely to seek information from students through questioning and discussion when compared to teachers with less content knowledge.**

StarrMatica's Virtual Science Coach (SVSC) was designed based on this foundation of research. SVSC uses easy-to-understand "bite-sized" resources to help teachers to intently focus on the high-impact strategies that research shows will improve science instruction - regardless of curricular materials. The pedagogy focused resources - namely productive questioning, discussion facilitation techniques, and science content knowledge - are delivered in an “on demand” platform that can be implemented by district personnel or used by individual teachers. This delivery model meets the time, location, sustainability, and ROI challenges of science professional development for districts of all sizes. The online convenience that allows educators to fit effective, research-based PD into their schedules is combined with the benefits of ongoing coaching through Zoom to ensure implementation fidelity, application of newly learned skills, the opportunity for extended learning, and collaboration with a network of like-minded educators. Instead of one-time workshops or online classes, the VSC provides a system for standardizing elementary science instructional expectations throughout a district for both current and future teachers.

As the recipient of highly competitive Small Business Innovation Research Grants, SVSC went through a rigorous research study in elementary classrooms across the country. Data was collected and analyzed by researchers at The University of Northern Iowa and The University of Nebraska-Lincoln. A brief description of each of the learning modules within SVSC follows along with research results.

Teacher need to be specifically trained to ask high-quality questions. And their questioning ability also improves with greater content knowledge.

The VSC uses easy-to-understand "bite-sized" resources to help teachers to intently focus on the high-impact strategies that research shows will improve science instruction.

The VSC incorporates ongoing coaching opportunities. And the platform provides a system for standardizing elementary science expectations throughout a district for current and future teachers.

The VSC has been piloted in classrooms around the country and has been through a rigorous research study with data collected and analyzed by external researchers.

A prototype of the VSC that only included lesson planning tools was piloted by six teachers in 2019. Data collected and analyzed by researchers at the University of Northern Iowa showed teachers were able to:

• Feel more confident creating a high-quality NGSS-aligned lesson regardless of previous training and experience as shown by a 1.5 point increase on a pre/post Likert survey.
• Spend less time developing their science lessons as shown by an average reduction of 2 hours in lesson planning time.
• Develop lessons that are better aligned to the NGSS as shown by all teachers scoring 18 out of 18 on the EQuIP Lesson Alignment Screener. Some teachers scored from 0 – 3 on pre-lessons and attained full alignment (18 points) on post lessons.

Using an early VSC prototype, teachers were able to create a fully-aligned NGSS lesson with an average reduction of 2 hours in planning time.

Phase I research also revealed that even though all teachers in the study developed lessons fully aligned to the NGSS, their science instruction (actually teaching the lesson) was only slightly more effective as measured by the Science Teacher Inquiry Rubric. On their pre lessons, teachers scored an average of 3.6 out of 24. The average score for post lessons only raised to a 6.6. **This significant finding means that even when teachers have curriculum materials that are fully-aligned to the NGSS, they are still not teaching in a way that will move student thinking forward.**

Even though the teachers' lessons were fully aligned, their science instruction did not improve significantly. This resulted in focusing the VSC on pedagogy.

Based on this research, the VSC was developed to be a robust professional development platform that helps teachers to improve their pedagogical content knowledge and questioning skills so they can effectively teach science regardless of their curriculum materials.

There are four sections to StarrMatica's Virtual Science Coach:

The Next Generation Science Standards Coach section of the VSC explains in great detail the “three-dimensional” structure of the standards and each of the science and engineering practices and crosscutting concepts. This set of standards is very different than previous standards, and teachers cannot teach the standards, evaluate curriculum materials for rigor, or develop lessons to meet the standards if they don’t understand what the standards mean!

The NGSS Coach helps teachers to understand the three-dimensional structure of the standards and each of the science & engineering practices and crosscutting concepts.

In our study, we measured teacher knowledge of the standards through questionnaires, pre and post quizzes, and a standardized assessment called the *New Framework for Science Education* that was designed to measure teacher knowledge of the three-dimensional nature of the NGSS. Data analysis of the *New Framework* assessment showed that all of our pilot study teachers moved from knowledge labeled as none, slight, and fair to solid, strong, and advanced across all 49 measurement questions.

Quantitative and qualitative assessments showed that teachers were able to increase their knowledge of the NGSS through their engagement with the VSC.

Teachers' post-use scores were significantly higher on average than their pre-use scores on all NFSE-STU subscales and the total scale. All differences were large in magnitude, with effect sizes ranging from 1.62 (Teaching Disciplinary Core Ideas) to 2.20 (Science and Engineering Practices). This indicates that teachers' NFSE-STU scores were higher after using the VSC platform by an average of 1.62 to 2.20 standard deviations, which translates to an increase of .45-.49 percentile points (from the 50th percentile to the 95th-99th percentile).

The teachers had statistically significant differences between pre- and posttest scores measuring their knowledge of the NGSS. The difference was large in magnitude and translated to an increase from the 50th to the 95th - 99th percentile.

On the pre and post quizzes, the median proportion of questions answered correctly was .76 before completion of the VSC NGSS professional development module and .91 after completion. Teachers' post scores were significantly higher than their pre scores, and this difference was large in magnitude (r = .89).

Individual teacher responses on our questionnaire supported the finding that teachers had significantly improved their understanding of the NGSS:

"My level of familiarity with the NGSS has definitely changed. I had not realized what all I was missing in my instruction. When my district first started looking at NGSS, it was overwhelming trying to understand what was needed. I feel now that I actually have a better understanding of what is expected at my grade level."

"Honestly, I had not thought about 3-dimensional instruction prior to using the VSC. It used to be just following the prompts of what was given in my curriculum and following the guidelines that were attached. Now going into the crosscutting concepts and science and engineering practices has made me realize how much more I need to be doing and making those connections."

The Questioning Coach section provides background on the importance of questioning in science, how to ask productive questions, how to respond effectively to student answers, and how to use talk moves to facilitate productive student discourse.

In our study, we measured the questioning skills of teachers through pre and post quizzes and video recorded lessons. Using a rubric, a qualitative analysis of those video transcripts is currently being conducted.

The median proportion of questions answered correctly on the pre and post quizzes was .77 before completion of the questioning lessons and .97 after completion. Teachers' post scores were significantly higher than their pre scores, and this difference was large in magnitude (r = .90).

Teachers' questioning quiz scores were significantly higher, and the difference was large in magnitude after completion of the questioning lessons in the VSC.

A sampling of individual teacher responses on our questionnaire related to questioning were as follows:

"My questioning practices have changed! I am still relying on the cards [she is referring to printable question reference cards within the VSC] but definitely have been able to have more discussions with my students. I can see a change in how I was presenting materials at the beginning of the school year compared to now. I think the last few lessons that I did were much more productive for the students."

"I am now a lot more thoughtful about creating a question that will truly make the students think. My questions try to help the students look back on their own background knowledge and experiences to help them answer using their own understanding."

The Science Knowledge Coach provides a content knowledge text (also available as an audio podcast) for each of the 76 performance expectations. These texts were written to provide teachers with the science content knowledge required to teach the performance expectation and answer related student questions. The engaging texts were written in "plain language" by a published author in conjunction with subject matter experts at the University level.

In our study, we measured teacher content knowledge through pre and post quizzes as well as the *Science Beliefs Test*. The median proportion of questions answered correctly on the quizzes was .70 before completion of the Science Knowledge Coach and 1.00 after completion. Teachers' post scores were significantly higher than their pre scores, and this difference was large in magnitude (r = .72).

Individual teacher responses on our questionnaire re-enforced the data:

"The background knowledge provided for NGSS and science concepts was thorough and plentiful. I feel more prepared to address student misconceptions and further their understanding of concepts after participating in this training and utilizing the VSC."

"It was wonderful to have accurate information in 'common terms' to help explain concepts."

"The information given in the Science Knowledge Coach modules are very informative. They give plenty of information for me as a teacher to be able to predict and answer any student questions."

Teachers also completed the Science Teaching Efficacy Beliefs Instrument which measures science teaching self-efficacy, or a teacher's belief in their ability to teach science. Teachers' post-use efficacy beliefs were significantly higher on average than their pre-use efficacy beliefs, and this difference was large in magnitude (0.89 standard deviations or an increase from the 50th percentile to the 81st percentile).

The Lesson Planning Coach explains of the characteristics of a high quality science lesson and provides a lesson planner to help teachers to take given curriculums, like Mystery Science, and improve them to be three dimensional or to write a rigorous lesson plan entirely on their own.

In summary, StarrMatica's Virtual Science Coach was designed based on decades of research and its effectiveness validated through an externally evaluated research study in classrooms across the country. I invite you to explore the enthusiastic testimonials on our website from fellow educators and then to contact us to learn how we can help you and your colleagues to improve science teaching in a way that fits your unique needs. Together, we can spark an interest in STEM for generations of students!

www.starrmatica.com/virtualsciencecoach

Analysis of pre- and post quizzes measuring science content knowledge shows that teachers were able to significantly increase their scores, and this difference was large in magnitude.

The teachers had statistically significant differences between pre- and posttest scores measuring their science teaching self-efficacy. The difference was large in magnitude and translated to an increase from the 50th percentile to the 81st percentile.

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