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Science in the Elementary Classroom

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Abstract

The elementary school day is filled with many different aspects of learning. Math and reading have been the emphasis of teaching over the last decade. Science is a part of students learning that needs to find its way into the elementary school day. This literature review compares different curriculum that is used to teach science in the elementary classroom as well as discusses an effective use of time to implement science into the daily schedule. When considering when and how to teach science, some teachers incorporate into other curricular areas as others find its own time during the day. Multiple studies were analyzed to determine the best curriculum and time to teach science as well as what professional development should include to help teachers feel confident in teaching science. Current literature suggests incorporating science into literature or in game form to help students with problem solving skills. Many skills taught and learned in elementary science carry over to essential skills for students to be successful in the world after school.

Keywords: Science, Elementary Classrooms, NGSS, implementation, curriculum

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Science in the Elementary Classroom

"Science at the elementary level plays a critical role in preparing students to think about and question science as both a body of knowledge and as a process of intereconnected concepts." (Rogers, 2009) Educators have incorporated Science into their classrooms by using cross curricular measures to cover science related material or just not taught science skills to young learners. In doing so, the problem solving, reasoning and questioning has not been used to teach the fundamentals of science. Research has been done to see the best way to teach science in the elementary classroom. "Incorporating nature of science into science education is an important goal for science education." (Licui & Sihan, 2019) A number of science education researchers have highlighted the distinction between pattern seeking and mechanistic reasoning." (Tang & Hammer, 2020)

Science has been pushed to aside in many elementary classrooms. This can be due to not enough time in the day and most of the time being spent on reading and math. Some schools have resorted to alternating between science and social studies to find enough time to teach both, while some schools do their best to incorporated Science into their reading curriculum. While this may not be the best way to teach Science, it is one way to teach science in the elementary classroom. "Engineering design-based instruction is becoming more commonplace in elementary classrooms. With the inclusion of engineering in the Next Generation Science Standards (NGSS) and the increasing emphasis on integrated STEM, the intent it not for engineering to be implemented as a separate subject but as an integral and integrated part of science instruction." (Tank, 2020). Giving students the opportunity to learn science and the many different aspects of science is important in the elementary classroom. The curriculum that is chosen by the district all plays a key role in how science is going to be taught in the elementary classroom. Research shows there are many ways to teach science and incorporate it in the classroom schedule.

This literature review will examine the strategies and curriculums to use for the best results when implementing science in the classroom. The purpose of this review is to determine the common way schools are doing to get students the science skills they need to be successful as well as how they are

implanting science skills into their classroom. This review will consider which curriculum is the most successful in teaching science during the school day. This will also discuss the key elements and ways to teach science to the young child. This review will cover many different curriculums that are available to schools as well as what science skills are key to teach the students. For the purpose of this review, the terms "science," "elementary classroom," and "curriculum" were used to search in several databases, including ERIC and ProQuest. Sources ranged from 2003-2020 publication dates. Those with older dates was research done in universities and studied teachers who were almost complete with their teaching degree and working with young students in student teaching or placement fields.

It is evident there are many science curriculums available to help in teaching science to the young child. In schools that have not been using a science curriculum, this will be a key piece in starting to teach science. This will require time by the teachers to get to know the curriculum as well as time during the day to teach the students the key principles of science.

In this review, evidence will show the positives and negatives of the different curriculums. Next, evidence-based teaching strategies will be examined to show the importance of using strategies as well as which ones are been found to be the most successful. "A wide range of teaching strategies was used by teachers in the class, e.g., lecture/questioning, hands on science activities, small group discussion, films, peer teaching, demonstrations and simulations." (Rice & Boychoudbury, 2003). Many of these are used in the classrooms today. Finding the right teaching strategy that fits the needs of your students is going to help determine which strategy is going to be successful. Finally, a case will be made as to how teachers can find time during their school day to teach science.

Review of the Literature

Next Generation Science Standards

"The rapid increase in knowledge, thanks to technology supported research, has led to the increase and change in information towards education, learning and teaching" (Yaman, 2017 p. 1). Next Generation Science Standards, also known as NGSS, are reshaping science education (Trygstad, 2013). These standards are three-dimensional and are specific in teaching scientific inquiry (Nollmeyer, Morrison, Baldwin, 2019). "The NGSS are written as performance expectations that blend the three dimensions of the framework: disciplinary core ideas, science and engineering practices, and crosscutting concepts. The three dimensions are written as learning progressions designed to build understanding at successively deeper levels, from kindergarten to 12, so teachers are challenged to guide students to learn core ideas through a process that mirrors what real scientists do" (Miller, 2015, p. 1). Introduced in 2013, this was a call for a significant shift in how science is taught. During the 2017-2018 school year, 11% of schools reported they had NGSS implementation occurring in their district (Tyler, Britton, Nilsen, Iveland & Nguyen, 2019). In today's learning, a downfall in education is student's inability to have a voice and choice in their learning. Thus, they can't share their experiences, thoughts or interests in their learning. The increase in knowledge about how students learn leads to the shift in practices to teach and learn science (Martin, 2012).

Engineering designed core ideas are the main focus and priority in science for kindergarten through grade twelve classrooms (Gale, Koval, Ryan & Usselman, 2018). The shift is moving away from memorization and towards teaching facts students can explore and use in their everyday phenomena as well as connecting facts or knowledge to science concepts (Zinger,

Sandholtz & Ringstaff, 2020). Science achievement gap is one that many scholars are working to close (Wenner, 2017). The concepts NGSS emphasize are cross cutting, core ideas and science practices, as well as trying to understand the discipline of science (Trygstad, 2013). Studies have shown there is a low success rate when it comes to science learning in the classroom (Armagon, 2015). In order for students to be motivated and challenged in their learning, creating a supportive learning environment can help when making this shift (Sazik, 2015). The standards are intended for all students (Miller, 2015). Engineering concepts are taught through the NGSS standards, fewer than 5% of elementary science teachers have had college courses in engineering (Trygstad, 2013). In a study by Trygstad, teachers were asked how often they teach science, 18% of grades K-2 classes and that number progressed to 29% for grades 3-5. (Trygstad, 2013). In terms of minutes, this would calculate out to 18 minutes for grades K-2 and for grades 3-5, 23 minutes (Trygstad, 2013). As stated by Trygstad, "It is clear that elementary school teachers do not feel equally prepared to teach all academic subjects, with perceptions of preparedness to teach science paling in comparison to reading/language art and mathematics" (Trygstad, 2013, pg 3-4). Making student work purposeful and meaningful is how NGSS is designed, which plays a key role in phenomena. There are three key criteria the phenomena use to create the vision of the framework. They are:

1. Phenomenon explanation or problem solving to develop or apply key elements of core ideas.
2. A sufficient number of performance expectation must be addressed to extend classroom time and see the connections in science ideas
3. Student interests and everyday experiences should connect with unit anchors (Penuel & Reiser, 2018).

In order for this criteria to be met, schools and districts will need to reflect on current reality of practices in science.

A gap in beliefs and practice may be able to be closed by providing teacher education and professional development (Nordine, 2021) as well as teachers feeling the pressure from their administration to fit science into their school day. (Bradbury, 2020). Elementary teachers have been found to not be confident in teaching the science curriculum. There is a lack of content and knowledge among most teachers for NGSS to be implemented successfully (Harris, Sithole, Kibirige, 2017). This means support is needed to help teachers in the area of science (Winn, 2016). To start down a path towards effective science instruction, teachers need to have more than just content knowledge, they need an understanding of science and the material they are teaching (Nordine, 2021). Changing the way science education has traditionally been viewed is from *knowing* science to being able to *use* science is the key shift in the framework (Penuel & Reiser, 2018). "In the elementary classroom, science instruction is critical for children's development of science concepts and ideas" (Zinger, Sandholtz & Ringstaff, 2020 p. 15).

The instructional practices Next Generation Science Standards promote;

- Asking questions and defining answers
- Using models
- Investigations
- Data interpretation
- Computational Thinking – Mathematics
- Designing solutions
- Evidence based argumentation

- Information – evaluating, communicating, obtaining (Amplify, 2017).

"Without more instructional time devoted to science, students will not have opportunity to engage with many of the concepts, ideas and practices described by NGSS" (Trygstad, 2013 pg 9). In turn, teachers of science need professional learning opportunities to ensure adequate time is being devoted to these concepts.

Assessments provide a major challenge in developing three-dimensional science learning as well as provide the evidence of the student's using their interest and engagement with the curriculum materials that were used (Penuel & Reiser, 2018). In a study by Bradbury states 50% of teachers felt pressured when it came to assessments (Bradbury, n.d.). New methods need to be developed to better prepare students for technology-dependent careers. Studies by Harris, Sithole and Kibirige have found there is a lack of science content and knowledge by teachers which created a lot of concern on the implementation of the NGSS standards (Harris, Sithole, & Kibirige, 2017). Research done by Rice shows when putting the teacher's confidence level on subjects they teach at the elementary level, science ranks eight out of eleven subjects (Rice, 2003). The NGSS framework is what is best for students to learn and apply science concepts. Teachers need to know and understand those standards, have professional learned to be able to plan for and implement, and be confident in their assessment of the standards.

Evidence Based Teaching Strategies

Teachers are doing amazing things each day in the classroom when it comes to science that have gone unrecognized (Miller, 2015). Teachers use instructional materials, as well as technology and play a crucial piece in the learning that takes place. Using these tools effectively in the classroom will help create the inquiry-based classroom needed in elementary schools for

students to be successful (Forbes, 2013). Effective classroom strategies are being used and are successful in the classroom. These strategies have made students able to use models to design and share solutions (Miller, 2015). Shifts in teaching and learning are required for innovations to take place from the way science was taught. Teachers and leaders have found people, policies, procedures and practices all impact the use of NGSS (Stiles, Mundry & DiRanna, 2017). Shifts need to be made in teaching practices to support the changes the NGSS is bringing to the science material that is being taught (Reiser, 2013).

1. Explaining phonemona needs to be the goal of instruction
2. Inquiry is not a separate activity
3. Building a coherent storyline across time (Reiser, 2013).

Curriculum materials used by each teacher and the way they are adapting these materials are impacting the learning that is taking place (Forbes, 2013).

Teacher leaders are essential part of implantation of the NGSS standards. (Tyler, Britton, Nilsen, Iveland, & Nguyen, 2019). Essential to the transition [to the NGSS] is a central office leadership team coupled with site-based leadership, consisting of individuals who collectively have the managerial authority to make changes such as setting budgets and hiring staff, expertise in science and science instruction, and the ability to communicate clearly with both internal and external stakeholders as well as allow time for professional learning and development. The leadership team should include members from both the district and school levels, education professionals who are engaged in implementation efforts, and a representative from an external partnership (Tyler, Britton, Nilsen, Iveland, & Nguyen, 2019, pg 1). Starting with working on teacher's self-efficacy, teacher leaders can prove to be effective. Teachers having confidence in teaching science will help in the preparation and instruction delivery (Yaman, 2017).

Science and engineering should start at the early grade levels and progress as the students get older. All the different grade levels have a need for opportunities to take part in investigations structured by their teacher and investigations based on their own questions and inquiries. Students should have opportunities to determine what problem needs to be solved and how data needs to be collected. They also need experiences outside of the classroom to learn how science takes place all around us (Duschl, & Bybee, 2014). Opportunities for practice need to be intentionally planned for students to experiment. Practice means more than just using the skills or processing the standards, it is understanding them. It means they are working to figure out an explanation or how to solve the problem. (Reiser, 2014). For students to grow in science, it needs to be taught at the younger levels so they benefit from their science knowledge. At a young age, students are curious as to how things work, that is the beginning of science (Brogdon, 2015).

Three-dimensional learning

Three-dimensional learning is not intended to be taught separately as independent learning targets that are assessed as separate skills and knowledge. They are indented to actually use science in applying scientific ideas (Penuel & Reiser, 2018). All three dimensions need to be used and integrated for students to understand phenomena (Krajcik, 2015). A critical role in science teacher education programs will help for a consistent in knowledge, beliefs and goals (Nordine, 2021). "A central shift in the framework and NGSS is bringing together science and engineering practices with science ideas being the definition of science literacy, rather than creating "content" and "process as separate learning goals" (Penuel & Reiser, 2018 p.3). Students that are using three-dimensional learning will be building models, designing investigations, sharing ideas, developing explanations and using evidence to argue their position.

In return, this will help create many twenty-first century skills, including problem solving, self-management, collaboration, critical thinking and most importantly communication. Three-dimensional learning should be planned for and used every day when teaching. It establishes a culture to help students figure out phenomena to problems. This will be a lifelong skill students are able to throughout their careers (Krajcik, 2015).

Materials

Like anything else, implementation is going to be a change that needs to be managed. An essential part of implementation is making sure all students are getting the science instruction they need (NextGen Science, 2017). “Curriculum frameworks should be used to guide the selection and development of units and courses of study.” (Lorsbach, 2008) Incorporating engineering into the elementary classroom would be meaningful for the students but may be difficult for teachers. (Tank & DuPont, 2020). Teachers are being reluctant to change and may not feel comfortable in the science instruction and curriculum. A study by Zinger, Sandholtz and Ringstaff show 17% of the teachers in their study reported needing more materials and resources, while 40% stated they needed a curriculum to teach science effectively (Zinger, Sandholtz & Ringstaff, 2020).

Coherent science instruction has been researched to show the meaning with instructional practices. Developing a small set of core ideas over a long period of time is the focus of this instruction. It also motivates students for a need to know based on new ideas with their ability to use the phenomena or problem solving to guide their learning. (Jeffrey, Sorge, Delen, Evans, Juuti, Lavonen, Nilsson, Ropohl & Stadler, 2021).

Game design was tested by Hodges, Flanagen, Lee, Cohen, Krishman and and Ward. This technique brought educational games into the classroom. After testing, they found that games that had a storyline increased learning gains. Using games when it comes to teaching and learning science are closing gaps. These games are taking the purpose and goals of the learning experience and are teaching self-efficacy, attribution theory and context-based material. When using the game theory, students are investigating, manipulating and exploring science in a different way (Hodges, Flanagen, Lee, Cohen, Krishman, Ward, n.d.).

In a study done by Banilower, many teachers feel uncomfortable when it comes to teaching science, (Banilower, 2013) and they many times face difficulties. (Licui & Sihan, 2020). Research done by Zinger, Sandholtz and Ringstaff states many teachers displayed challenges in the use of the science curriculum. Many of these challenges dealt with hands on experiments as they did not have access to the tools or materials required. Curriculum played a big part in what teachers were teaching. NGSS lacked curriculum that was aligned which in return created a time pressure for elementary teachers (Zinger, Sandholtz & Ringstaff, 2020). Teachers need to be precise on their explanation and give students the opportunity to engage in science reasoning (Tang & Hammer, 2020). This means having materials and resources that, when combined with evidence-based teaching strategies, are crucial to success in science.

The traditional textbook and curriculum materials give the students key parts for disciplinary core ideas but asking students to explain them fails in reflecting the three-dimensional aspect of lessons (Penuel & Reiser, 2018). Traditional curriculum materials are those that are organized differently. They are organized using the logic of discipline (Reiser, 2013). Many times, these textbooks do not have accurate representations and may not provide any instructional guidance (Licui & Sihan, 2020). Providing differentiated support and equity is

the primary job of the curriculum materials. They also need to provide and integrate an array of assessment activities to provoke student thinking (Penuel & Reiser, 2018). "Houghton Mifflin Harcourt, McGraw-Hill, Pearson and Delta Education have been common all curriculum based text books used in the elementary classrooms (Nordine, 2021). Textbooks have been providing teachers with insufficient explanations, therefore providing inadequate knowledge to the students (Hacieminoglu, 2014). Materials used for teaching science will need to explore investigation strategies and how core ideas are built across lessons to create instructional shifts more concrete (Penuel & Reiser, 2018). Some of the struggles in elementary students learning science is the vocabulary that is associated with science curriculum. Students have a hard time comprehending the vocabulary which makes it hard for them to learn the concepts (Tank & Coffino, 2014). "It is clear from the analysis that curriculum materials and assessments that reflect NGSS-aligned approaches by themselves will not be enough, unless teachers can support the students' science practices as targeted in NGSS-aligned curriculum materials and assessments (Reiser, 2013).

Amplify

"Amplify science is a highly engaging, phenomena-based program for grades K-8 that integrates the latest practices in science teaching and learning, as well as interactive digital tools and hands-on activities, to teach students how to think, read, write, and argue like real scientists and engineers" (Amplify Science, 2019, p.1). This curriculum meets criteria for Tier III which provides education intervention with ESSA (Every Student Succeeds Act) and meets all the Next Generation Science Standards. Amplify curriculum provides lesson plans with detail for teachers to follow, hands on activities and materials, scientific texts, digital simulations and models, topics for discussion, formative and summative assessment as well as supports for teachers with

options for professional development. Students engaged in this curriculum learn to read, write and think like a scientist. Amplify's curriculum has;

- Emphasis on coherence
- Exploration of phenomena
- Real world problems and roles
- Investigation opportunities

Do, Talk, Read, Write is the model used as the instructional approach for Amplify. This correlates with effective science knowledge as well as literacy development. Research done shows Amplify proves that students learn science and while doing so strengthen their reading comprehension (Amplify Science, 2019).

Mystery Science

Mystery Science is an internet based, hands on NGSS and common core aligned science and engineering curriculum. It is the most widely science resource used in schools. The curriculum provides open and go lessons that are inspiring students to love science. It is proven the first years of a child's life form habits that are with them the rest of their life. Mystery Science takes questions from children all around the world and creates video explanations. It is not only answering the why to the question but gives students step-by-step guides for anything they want to do (Mystery Science, 2021). The purpose of Mystery Science is to "ensure the next generation of children grow up and see that it's an amazing world we live in, full of possibility and wonder-and that they develop the ability to figure things out for themselves" (Mystery Science, 2021, pg 1). Research showed teachers and parents wanted help with questions that children asked and how they could answer those questions. Focusing on these questions,

Mystery Science found this way of answering their questions made a difference with the students (Mystery Science, 2021).

Time

A major instructional challenge within science is the use of time in the elementary classroom. Not just the time for instruction being an issue, but the time to plan and collaborate with others in their building and time to plan lessons were all challenges. (Zinger, Sandholtz & Ringstaff, 2020). A study done by Zinger, Sandholtz and Ringstaff show 100% of all teachers in their study reported time being in used in teaching science (Zinger, Sandholtz & Ringstaff, 2020). In the elementary classroom, reading, writing, math and high stakes testing are taking priority of the school day. This means science and social studies are not getting the time they need at the elementary level (Berg & Mansah, 2014). "One condition that is necessary is that schools allocate sufficient regular time to teach science, especially at the elementary level (National Research Council, 2013). An instructional challenge teachers struggle with, is the lack of time in their day to teach science. Time not only to teach the students, but also for planning (Zinger, Sandholtz & Ringstaff, 2020). A study by Berg and Mensah found 66% of teachers say science requires more effort to teach than other subjects (Berg & Mensah, 2014). Teaching science in the elementary classroom is difficult due to the having to teach multiple subjects in the short school day. These include language arts, math, social studies and science (Zinger, Sandholtz & Ringstaff, 2020). Research shows student's achievement scores have increased when integrating math and science curriculum (Martin, 2011). Professional development is needed to do implement science in the elementary school day effectively.

Professional Development

"It is widely agreed that professional development is the key to reform, and that ongoing support situated in teachers' classroom practice is the optimal form of professional development" (Berg & Mensah, 2014). An effective science curriculum that is matched with professional development for teachers and provides assessment activities as well as providing a curricular activity system will really help elementary teachers (Penuel & Reiser, 2018). Research shows, effective professional learning should start with pre-service teachers towards their teaching practice. This will help in shaping their teaching practices at an early stage in their teaching career (Jeffrey, Sorge, Delen, Evans, Juuti, Lavonen, Nilsson, Ropohl & Stadler, 2021). 92% of new teachers in the state of Iowa responded favorably when asked about the support they received on effective teaching practices (TLC, 2019). It was also shown that 92% of all Iowa schools met their goal of retaining new teachers due to mentoring programs (TLC, 2019).

Professional development should involve examining the materials. This is a key component of teachers shifting their teaching. Using examples of how to work through student questions and navigating through the material are all important uses of professional development time. The goal of the material is to help guide teachers in making instructional decisions. Time is needed to be able to effectively plan for that.

Science focused professional development is something only half of elementary teachers said they were a part of in the last three years. As well as about 15% of teachers have never participated in professional development on the topic of science (Nordine, 2021). Teaching teachers the underlying purposes and important structures of the curriculum. This will provide teachers the integrity to adapt materials (Davis & Varma, 2008). Professional development

should also align with the expectations to support student's engagement and produce activities that are engaging as part of the materials provided. Using the goals of the district, the professional development needs to be sustained over time (Penuel & Reiser, 2018). The major shift in NGSS is treating science as separate learning targets instead having the focus on using engineering practices to build science ideas and find a way to correlate how the students can use those skills in the world (Penuel & Reiser, 2018). Experts and those outside of the school are a great resource to provide professional development as well as time to collaborate with other teachers within the school (Zinger, Sandholtz & Ringstaff, 2020). Reiser discusses four related four characteristics of professional development to be successful.

1. Professional development should be embedded in subject matter.
2. Professional development needs to be active in learning.
3. Professional development needs to be connected to teachers' own practice.
4. Professional development needs to be part of a coherent system of supports (Reiser, 2013).

Teachers need the opportunity to work with the curriculum. This includes analyzing cases and applying the strategies they are teaching to the students. There also needs to be time for teachers to understand the new material and think about and plan what that would look like in their classroom and with their students. Professional development should consist of extensive hours with time spread in the school year or even summer workshops. Contrary to the traditional one-shot workshop, working with a curriculum for a couple hours, teachers need the opportunity to apply these changes in their own practice (Reiser, 2013).

Studies show a correlation between science teaching and instructional leadership (Winn, 2016). Science teacher leaders is thought of as unique (Wenner, 2017). This leader would work

with teachers to help close science achievement gaps (Wenner, 2017). Winn states, "When principals work as instructional leaders to coordinate the curriculum, they work to ensure that the curriculum matches the enacted lessons, which in turn match the assessments" (Winn, 2016). When thinking about principals as instructional leaders, 21% of principals have earned a degree in a science related field. In fact, 13% of principals were at one time a science teacher (Winn, 2016). Principals have a pull in what is being taught and what curriculum is being used. Therefore, their background may play a role in what is being done at their school (Winn, 2016).

Conclusion

A lack of teaching elementary skills and knowledge will result in NGSS science standards not being mastered and students missing problem solving skills that are essential to be successful (Harris, Sithole & Kibirige, 2017). Having teachers that feel comfortable teaching science is going to impact how science in taught and what material is being taught even when it comes to different attitudes and experience levels. (Sakiz, 2015). Teaching behaviors help build student confidence (Rice & Roychoudhury, 2003). The change in technology has made a change in the way teachers deliver material. Finding a way to use technology when teaching science will help incorporate the standards of NGSS (Harris, Sithole & Kibirige, 2017).

Throughout the literature review, research was shared to help provide guidance and suggestions on the best curriculum and ways to incorporate science into the elementary daily classroom. While some teachers incorporate science into other curriculum times, science teaches many skills to students that will help in other curricular areas. Science has been shown to bring out three emotions when it is taught in the classroom: student enthusiasm, teacher enthusiasm and teacher happiness (Bradbury & Wilson, n.d.). Whether it be taught integrated with other curriculum areas or on its own, there is value in teaching science in the elementary classroom;

students need to be to articulate science understandings and it shows value in vocabulary learning (Tank & Coffino, 2014)

Due to the changes in standards, it is important teachers are involved in professional development to stay current with materials and instructional strategies. Administrators favor the inclusion of science in the elementary classroom and encourages guided instruction opportunities to help students explore and develop conclusions (Brogdon, 2015). Professional development has shown to be essential when it comes to effective science instruction. Teachers need the opportunity to work with the materials and shift their teaching to feel confident in teaching science (Reiser, 2013).

Maximizing time in the elementary classroom will help create an opportunity for science to be taught. Utilizing professional development to get familiar with curriculum (Reiser, 2013) and finding a curriculum that fits the students need may help increase the effort of getting science into the elementary classroom.

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