

EARLY CHILDHOOD EDUCATION: STEM (NWTC)



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ECE: STEM (NWTC)

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CHAPTER OVERVIEW

1: Introduction to STEM

1.1: What is STEM?

1.2: Strategies for Asking Questions

1.3: The Educator's Roles and Responsibilities in STEM

1.4: STEM Play Experiences Promote Learning

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1.1: What is STEM?

COURSE COMPETENCY 1. Explain the basic concepts of science, technology, engineering, and math (STEM)

Criteria 1.1 Identify the guiding principles of STEM.



STEM is an acronym for Science, Technology, Engineering and Math:

- **Science** – Observing, making connections, coming to conclusions, and asking questions about how things work. For preschool-age children, science-related learning activities might include exploring water and sand, comparing natural materials like rocks and soil, rolling balls across the room, and looking through a magnifying glass to count how many legs are on the bug that was caught during outdoor play.
- **Technology** – Using tools, identifying problems, and trying different solutions. Technology-related learning activities for preschool-age children might include identifying simple machines like gears, wheels, and pulleys. It may also include simple coding, where children learn how to program little robots to do simple tasks.
- **Engineering** – Using tools, identifying problems, designing, and creating solutions, and building and inventing things. Engineering activities can happen in the building blocks play area, where preschool-age children plan and design structures every day with little teacher direction.
- **Math** – Sequencing, measuring, counting, patterning, exploring shapes, comparing size/weight/volume/height/distance. Math-based learning activities in the preschool classroom include counting, matching shapes, and making patterns. Measuring is easy too, especially with unit blocks where children discover that two of the same-sized blocks equal one of the next size up.

Teaching STEM provides opportunities for children of all ages to develop 21st-century skills such as:

- **Problem-Solving:** STEM learning experiences require children to use critical thinking skills to identify a problem and create solutions.
- **Adaptation:** The ability to modify a learned concept to fit a different version of an issue or problem.
- **Creativity and applying knowledge:** STEM allows children to master real-world skills through experimentation and doing. Being able to immediately apply newly gained skills is a strong motivator for learning.
- **Decision-making:** All four components of STEM can provide opportunities for children to practice assessing options and making decisions based on those assessments.
- **Media and Technology Literacy:** It is critically important that children embrace the use of technology at an early age so that they are comfortable with innovative technologies they will be exposed to throughout their lives.
- **Teamwork:** STEM learning experiences lend themselves to working together in groups to identify problems and come up with solutions.
- **Risk-taking and experimentation:** Learning by experimentation and doing is inherently risky, as the results are initially unknown. Exposure to managed risk-taking allows children to become comfortable with their ability to take risks.
- **Social skills:** working in groups promotes social skills such as cooperating, negotiating, listening, following instructions, and turn-taking.
- **Communication skills:** To be an effective member of a team, children need to be able to communicate their thoughts, ideas, and discoveries to the group.
- **Resilience:** Learning through experimentation and doing will inevitably expose children to failure. STEM learning experiences teach children that making mistakes is a valuable step in learning.

(Adapted from [How to Teach STEM to Preschool Children Through Play](#))

Indigenous Perspective

A holistic approach to education focuses on the interconnectedness of various aspects of learning and personal development, aiming to nurture the whole individual - mind, body, and spirit. Similarly, the perspectives of the Oneida Nation emphasize a holistic worldview, rooted in the interconnectedness of all living beings and the environment. Here are some key similarities between a holistic approach to education and the perspectives of the Oneida Nation:

1. **Interconnectedness:** Both perspectives recognize the interconnectedness of all aspects of life. In education, this means understanding that learning is not isolated to academic subjects but also involves physical, emotional, and spiritual growth. In Oneida perspectives, this interconnectedness extends to the relationship between humans, the natural world, and the spiritual realm.
2. **Respect for Diversity:** A holistic approach to education values diversity and recognizes the unique strengths and perspectives of each individual. Similarly, the Oneida Nation emphasizes respect for diversity among individuals, communities, and ecosystems, honoring the contributions of each.
3. **Cultural Relevance:** Both perspectives prioritize cultural relevance and the integration of traditional knowledge and wisdom into educational practices. For the Oneida Nation, this may involve incorporating traditional teachings, languages, and practices into educational curricula to ensure the preservation and revitalization of cultural heritage.
4. **Community-Centered:** Holistic education and Oneida perspectives both prioritize community well-being and involvement in the educational process. In a holistic approach, community engagement fosters collaborative learning experiences and supports the holistic development of individuals within the context of their communities. Similarly, the Oneida Nation emphasizes the importance of community support and collaboration in all aspects of life, including education.
5. **Sustainability:** Both perspectives emphasize the importance of sustainability and stewardship of the environment for future generations. Holistic education often includes teachings about environmental responsibility and ecological awareness. Similarly, the Oneida Nation's traditional values include a deep respect for the land and a commitment to living in harmony with nature.

In summary, a holistic approach to education shares many similarities with the perspectives of the Oneida Nation, as both emphasize interconnectedness, respect for diversity, cultural relevance, community-centeredness, and sustainability. By

integrating these principles into educational practices, educators can support the holistic development of individuals while also honoring indigenous perspectives and knowledge systems.

(OpenAI. (2024). ChatGPT (3.5) [Large language model]. <https://chat.openai.com>)

Early Childhood Educators as Co-learners

Unfortunately, it is not uncommon for early childhood educators to feel unprepared to teach science, technology, engineering, and math. They may be afraid of not knowing the right answers to children's questions or providing the wrong answer. Developmentally appropriate STEM activities during the early years focus on developing STEM skills, not STEM knowledge. When viewed through this lens, educators become co-learners rather than the source of knowledge.

? Pause to Reflect

Many adults (including parents and teachers) shy away from science and math because they “aren’t good at it.” How do you feel about science and math? How comfortable are you “teaching” engineering and technology? What are your concerns or questions?

Important Things to Remember

- Science, technology, engineering, and math are embedded in children's daily activities and play and provide a natural vehicle for integrating concepts that cross content areas.
- Developmentally appropriate STEM activities during the early years focus on developing STEM skills, not STEM knowledge. When viewed through this lens, educators become co-learners rather than the source of knowledge.
- Educators' thoughtful guidance and support through inquiry experiences build a foundation for children's understanding of basic science, technology, engineering, and math concepts, foster a positive approach to learning, and develop learning skills and attitudes necessary for success later in life.
- Science during the early years is about active learning, not memorizing scientific facts or watching the educator perform science demonstrations. The purpose of science experiences is to nurture children's habits of inquiry, critical thinking, creativity, innovative problem-solving, open-mindedness, and the motivation to learn.
- Developmentally appropriate technology activities during the early years are hands-on, with minimal use of screens.
- Scientific inquiry involves the formulation of a question that can be answered through investigation, while engineering design involves the formulation of a problem that can be solved through design.
- Learning mathematics grows naturally from children's curiosity and enthusiasm to learn and explore their environment. During the early years, children continue to show a spontaneous interest in mathematics and further develop their mathematical knowledge and skills related to numbers, quantity, size, shape, and space.

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1.2: Strategies for Asking Questions

COURSE COMPETENCY 1. Explain the basic concepts of science, technology, engineering, and math (STEM)

Criteria 1.2 Use a variety of questioning methods.



Questioning Methods for Early Childhood

Early childhood teachers can help young children learn STEM concepts by being intentional in the types of questions they ask. This means teachers purposefully plan the types of questions they will ask.

Using a variety of questioning methods in early childhood STEM education is crucial for several reasons:

1. **Cognitive Development:** Different types of questions (open-ended, closed-ended, probing, reflective) stimulate various cognitive processes such as critical thinking, problem-solving, and creativity. This variety supports holistic cognitive development in young children.
2. **Engagement:** Varied questioning keeps children engaged and interested in the learning process. It encourages active participation and exploration, leading to deeper understanding and retention of STEM concepts.
3. **Different Learning Styles:** Children have different learning styles and preferences. Some may excel with open-ended questions that encourage exploration and experimentation, while others may benefit from structured, closed-ended questions to grasp foundational concepts. Using a mix caters to these diverse learning needs.
4. **Communication Skills:** Different questioning methods help children develop communication skills. Open-ended questions promote verbal expression and articulation of thoughts, while closed-ended questions can reinforce vocabulary and comprehension.

5. **Problem-Solving Skills:** By encountering various types of questions, children learn to approach problems from different angles, develop analytical skills, and become more adept at finding solutions independently or collaboratively.

Incorporating a range of questioning methods ensures that children receive a well-rounded STEM education that fosters critical thinking, engagement, communication, and problem-solving skills essential for their future academic and professional success.

(OpenAI. (2024). ChatGPT (3.5) [Large language model]. <https://chat.openai.com>)

Below you will see different questioning strategies to use with children. The strategies are adapted from the Head Start Early Childhood Learning and Knowledge Center presentation [Asking Questions, Birth to 5](#)

Questioning Strategies for Young Infants

Ask, wait, watch, and wonder?	• Ask a question. Use your body, language tone and facial expressions to animate the question. • Slow down your speech so that the infant can follow you. • Wait for a response. Watch for facial expressions, gestures, and body language. Listen for vocalizations such as coos, squeals, and babbling. • What is the infant trying to tell you? Respond back using similar vocalizations and facial expressions. • Repeat!
Ask children about what they see, do, and feel.	• You're reaching for the ball. What are you going to do with it? • Where are you crawling to? • How can you make the rubber ducky squeak? • Which book shall we read today? • Let's look out the window. What do you see?
Ask questions that help children connect to their own lives.	• Let's look at this family photo albums together. Who is holding you? • Where is your belly? • Are you letting me know you want me to pick you up? • Which bib would you like be to put on you—the smooth one or the soft one?

Questioning Strategies for Older Infants and Toddlers

Ask children about what they see, do, and feel.	• Where are you going to play next? • What do you see on this page?
Ask questions that help children connect with their own lives.	• Let's look at this family photo album together. Who do you see in these photos? • Where should we hang your picture? • You're rubbing your eyes. How do you feel?
Ask children to make predictions.	• What do you think will happen if you put one more block on top of the tower? • What will the caterpillar eat next? (The Very Hungry Caterpillar?)
Ask children to explain something or solve a problem.	• What can we use the box for? • Why do you think the block tower fell down? • How can we bring all of these balls outside?

Questioning Strategies for Preschoolers

Ask children what they are doing.	• What are you working on? • You are working very hard, tell me about your project. • What are your plans for those materials?
Ask children to provide explanations.	• Why do you think that happened? • How can I help you solve this problem? • I am wondering, how did you do that?
Ask children to make predictions.	• What do you think will happen next? • What could we use this container for? • What would you do if that were you?
Ask children to connect learning to their own lives.	• What do you think about? • How did you do that before? • What does this remind you of?

Supplemental Resources

See these links for resources to use in your classroom.

[A Guide to Asking Open-Ended Questions](#)

[Ways to Ask Young Infants Questions](#)

[Ways to Ask Older Infants and Toddlers Questions](#)

[Ways to Ask Preschool Children Questions](#)

1.2: [Strategies for Asking Questions](#) is shared under a [CC BY-NC](#) license and was authored, remixed, and/or curated by Vicki Tanck (Northeast Wisconsin Technical College).

1.3: The Educator's Roles and Responsibilities in STEM

COURSE COMPETENCY 1. Explain the basic concepts of science, technology, engineering, and math (STEM)

Criteria 1.3 Identify the teacher's role in high-quality, developmentally appropriate STEM experiences.



The Multifaceted Role of the Early Childhood Educator in STEM Experiences

Educators do not need to have answers to all the questions children will raise. Rather than providing children with answers, the educator can use children's questions as a springboard for further investigations. They may say, "I don't know. Let's find out together." It is essential that educators become learners together with children, model a questioning mind for children, and think aloud, expressing interest and enthusiasm. Educators' thoughtful guidance and support through inquiry experiences build a foundation for children's understanding of basic science, technology, engineering, and math concepts, foster a positive approach to learning, and develop learning skills and attitudes necessary for success later in life.

The following principles guide educators in establishing a preschool STEM program that fosters children's curiosity and develops their skills and habits to explore and learn about their world. These principles are consistent with a constructivist approach to learning, where children actively construct knowledge through physical and mental interactions with objects and people in their environment. The principles are drawn from current research-based models and approaches to early childhood education and are consistent with the National Association for the Education of Young Children (NAEYC) guidelines on developmentally appropriate practice.

- The preschool environment supports children's curiosity and encourages inquiry and experimentation.
- The educator
 - acts as a researcher, joining children in exploring their world
 - asks open-ended questions to encourage children to think and talk
 - introduces children to new vocabulary, including scientific, technology, engineering, and math terms such as observe, explore, predict, and measure
 - demonstrates appropriate use of scientific, technology, and engineering tools
 - invites children to reason and draw conclusions
 - encourages children to share their observations and communicate their thoughts
 - models respect for nature
- The content of inquiry is developmentally appropriate and builds on children's prior experiences
- Scientific inquiry experiences are interesting and engaging for children and educators
- Children explore concepts directly through active, hands-on, minds-on playful experiences
- Children explore concepts in depth through multiple, related learning experiences over time

- Children construct knowledge through social interactions with peers and adults
- Children use language and other forms of communication to express their thoughts, describe observations, and document their work
- Science, technology, engineering, and math are embedded in children's daily activities and play and provide a natural vehicle for integrating concepts that cross content areas
- Individual differences are recognized, and all children are included and supported
- To provide culturally appropriate and diverse objects, materials and toys.
- The preschool environment, home, and community are connected through science

Indigenous Perspective

Reciprocal learning in early childhood education refers to a collaborative approach where both educators and children actively engage in the learning process, sharing knowledge, ideas, and experiences. Similarly, the Oneida Nation's traditional perspectives emphasize reciprocity and the sharing of knowledge within the community. Here's how reciprocal learning in early childhood education aligns with the values and perspectives of the Oneida Nation:

1. **Interconnectedness:** Reciprocal learning acknowledges the interconnectedness of learners and educators, recognizing that everyone has valuable insights to share. Similarly, the Oneida Nation values interconnectedness among community members, fostering a sense of collective responsibility for the well-being and education of children
2. **Respect for Indigenous Knowledge:** Reciprocal learning in early childhood education emphasizes the importance of incorporating diverse perspectives, including indigenous knowledge and cultural traditions. The Oneida Nation's perspectives prioritize the preservation and transmission of traditional knowledge, ensuring that children are exposed to their cultural heritage from a young age.
3. **Community Involvement:** Both reciprocal learning and Oneida perspectives emphasize the importance of community involvement in the educational process. In early childhood education, this may involve collaboration between educators, families, and community members to support children's learning and development. Similarly, the Oneida Nation values community support and collaboration in all aspects of life, including education.
4. **Cultural Relevance:** Reciprocal learning promotes cultural relevance by incorporating children's cultural backgrounds and experiences into the curriculum. Similarly, the Oneida Nation emphasizes the importance of cultural relevance in education, ensuring that children learn in ways that are meaningful and respectful of their cultural identity.
5. **Empowerment:** Reciprocal learning empowers children to take an active role in their own learning, fostering autonomy and self-confidence. Similarly, the Oneida Nation's perspectives prioritize the empowerment of children, teaching them to be active participants in their community and to contribute to the collective well-being.

By incorporating reciprocal learning principles into early childhood education, educators can create inclusive and culturally responsive learning environments that align with the values and perspectives of the Oneida Nation. This approach honors indigenous knowledge and traditions while also promoting the holistic development of children.

(OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>)

The Educator's Role in Facilitating Play-Based Learning

The **NAEYC Professional Standards and Competencies for Early Childhood Educators** help us understand the multifaceted role of educators in facilitating play-based experiences for children. Educators must:

- create supportive environments,
- observe and assess children while they play,
- engage in responsive interactions,
- collaborate with families, and
- engage in continuous professional growth.

Standard 4 and Standard 5 apply to the multifaceted role of early childhood educators during play-based experiences.

STANDARD 4: Developmentally, Culturally, and Linguistically Appropriate Teaching Practices

Early childhood educators understand that teaching and learning with young children is a complex enterprise, and its details vary depending on children's ages and characteristics and on the settings in which teaching and learning occur.

STANDARD 5: Knowledge, Application, and Integration of Academic Content in the Early Childhood Curriculum

Early childhood educators have knowledge of the content of the academic disciplines (e.g., language and literacy, the arts, mathematics, social studies, science, technology and engineering, physical education) and of the pedagogical methods for teaching each discipline.

(See: [NAEYC's Early Childhood Higher Education Accreditation Standards](#) for more information.)

Types of Play-Based Learning

According to Danniels and Pyle (2018), there are two types of play-based learning: free play, which is child-directed and internally motivated, and guided play, in which some adult involvement extends the learning opportunities within the play. (CECE Practice Note: Play-Based Learning, p.2).

Educators can support play-based learning with the following:

- Interact with children in their play to extend their thinking and learning opportunities.
- Create schedules that allow for uninterrupted and extended periods of play.
- Co-plan future experiences based on observations of children's play.
- Document children's learning play to make learning visible.

NAEYC's guidelines and recommendations for developmentally appropriate practice are based on nine principles and their implications for early childhood education professional practice. **Principle 3** states: Play promotes joyful learning that fosters self-regulation, language, cognitive, and social competencies as well as content knowledge across disciplines. Play is essential for all children, birth through age 8. The recommendation goes on to further state the importance of both free play and guided play. For more information see [Principles of Child Development and Learning and Implications That Inform Practice](#)

The **Wisconsin Model Early Learning Standards (WMELS)** also have Guiding Principles and recognize the importance of play in a child's learning and development. The following principles reflect the importance of teachers and families providing play-based experiences for young children. **Children learn through play and the active exploration of their environment.**

The Wisconsin Model Early Learning Standards reflect the belief that children should be provided with opportunities to explore and apply new skills through child-initiated and teacher-initiated activities and through interactions with peers, adults, and materials. Teachers and families can best guide learning by providing these opportunities in natural, authentic contexts. Positive relationships help children gain the benefits of instructional experiences and resources. (See [Wisconsin Model Early Learning Standards](#), pg. 10)

The Educator's Role in Supporting the Active Construction of Knowledge

Educators play a pivotal role in children's active construction of knowledge. They intentionally provide the environments and experiences that support children in actively building concepts and skills. The role of the educator who works with young children birth to age five is to support children's active construction of knowledge. In a sense, early childhood educators serve as research supports as the children sense, discover, and construct meaning about the world around them. Young children's natural impulse to learn by investigating (1) what things are like and what they can make them do, and (2) how people create and share meaning shapes the role of the early childhood educator. The early childhood educator is responsible for: offering children well-stocked play spaces where they can construct concepts and ideas, preferably in the company of friendly peers; designing daily routines that invite children to be active participants and to use emerging skills and concepts; supporting children's learning through interactions and conversations that prompt using language and ideas in new ways and that promote sharing meaning with others.

In carrying out those responsibilities, educators create contexts in which young children can:

- Wonder about what things are like and what they do.
- Investigate a variety of ways of relating one thing to another.
- Invent problems and solutions with others; construct, transform, and represent with the materials at hand.

- Create and share meaning and collaborate in learning.
- Try new challenges and practice emerging skills.
- Express their emotions, feel secure to explore, and regulate their emotions and behavior.
- Manage conflicts in ways that support the development of social skills by:
 - Advocating for one's own needs, safety, and feelings.
 - Learning how to connect with their peers in mutually beneficial ways.
 - Learning how to walk away or disengage from their peers when they feel the need to.
 - Learning how to cope with feelings of rejection or exclusion. And in turn, learning how to seek out positive relationships, rather than dwelling on unsatisfying ones.

Indigenous Perspective



Figure 1 Generations of Indigenous people (Image provided by author)

The Oneida Nation, like many Indigenous communities, places a significant emphasis on passing on knowledge to the next generation. Central to their cultural values is the idea of intergenerational learning and the transmission of traditional knowledge, language, and customs. Here are some key aspects of how the Oneida Nation views this responsibility:

1. **Oral Tradition:** The Oneida Nation values oral storytelling as a means of passing down history, cultural practices, and spiritual beliefs from one generation to the next. Elders play a crucial role in this process by sharing their wisdom and experiences with younger community members.
2. **Cultural Education:** The Oneida Nation emphasizes the importance of teaching their language, traditional crafts, dances, songs, and ceremonies to younger members. These cultural elements are seen as essential for maintaining their identity and connection to their heritage.
3. **Community Involvement:** The community as a whole is involved in the education and upbringing of children. Extended family members, tribal leaders, and community elders all contribute to the learning process, ensuring that children receive a holistic education that encompasses both traditional knowledge and modern skills.
4. **Respect for Nature:** The Oneida Nation often teaches environmental stewardship as part of passing on knowledge. This includes teachings about the land, plants, animals, and how to live in harmony with nature, reflecting their deep connection to the environment.
5. **Adaptation to Modern Times:** While preserving traditional knowledge is crucial, the Oneida Nation also recognizes the importance of adapting to modern times. This includes incorporating relevant skills such as technology, healthcare, and education that can empower younger generations to thrive in contemporary society while maintaining their cultural identity.

Overall, the Oneida Nation's approach to passing on knowledge is rooted in a deep respect for their cultural heritage, a commitment to community involvement, and an understanding of the need to adapt to changing times while preserving their identity.

(OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>)

Early childhood educators see and support children as scientists and thus design the play environment to serve the children's inquisitive minds. Educators also provide the materials children need to construct concepts and ideas and achieve skills in the natural context of play.

Children learn from opportunities to discover materials that they may be seeing for the first time and need time to explore and get to know the properties of these materials. It means offering children materials that they can organize into relationships of size, shape, number, function, and time. Children can investigate what happens when they put these materials together or arrange them in new ways, experiencing the delight of discovering possibilities for building with them, transforming them, or using them to represent an experience.

Early childhood educators also design daily routines as rich opportunities for children to participate actively and to use their emerging skills and ideas in meaningful situations. Equally important are the ways in which educators use interactions and conversations with children to support learning. Many interactions occur spontaneously, with the educator being responsive to an interest or need that a child expresses. Many other interactions focus on co-creating or co-constructing meaning as the educator and a child or small group of children focus on a specific topic or activity.

Some interactions may include providing guidance to help children learn to regulate their emotions and behavior or may involve an intervention in which the educator helps children explore how to negotiate a solution to a conflict.

Other interactions and conversations teachers have with children are more predictable. Educators anticipate and organize some interactions and conversations as group discussions, to prompt children's thinking and understanding. Sometimes these groups are small, and sometimes, at preschool age, they are somewhat larger. Educators also guide some activities in a context that allows children to encounter new information and build skills. All interactions are embedded in contexts in which the children are actively engaged in exploring their own developing skills, learning from each other, and acquiring knowledge.

While play occurs naturally, educators must consider the following responsibilities when facilitating appropriate and purposeful play:

Spaces

- Are safe places to explore
- Reflect the mission and core values of the program
- Include culturally sensitive materials to explore
- Include open-ended materials for multi-use

Routines

- Are consistent and predictable
- Provide ample time for unstructured play to occur (Recommendation is 45 minutes minimum). If children aren't provided enough time to become immersed in play, they will be less likely to engage enough to receive the benefit of the activity.

Interactions

- Stimulate creativity by asking open-ended questions or reflective observations
- Respect individual differences in play and interactions
- Encourage cooperation

Educators who are deliberate and purposeful in what they do:

- Promote children's learning through worthwhile and challenging experiences and interactions which foster high-level thinking
- Seize opportunities during experiences and conversations to extend children's thinking and learning
- Model and demonstrate active listening skills
- Utilize varied communication strategies, such as open questions, explanations, speculation and problem-solving
- Move flexibly in and out of various roles and draw on different strategies as the context changes
- Draw on contemporary theories and research for their knowledge and practices
- Monitor children's well-being, life skills, and citizenship, and use the information to guide program planning
- Monitor children's needs and interests and incorporate them into program planning
- Identify 'teachable moments' as they arise and use them to scaffold children's learning and development.



Figure 2: Extending children's learning through conversation (Photo by [Yan Krukau](#) on [Pexels](#))

? Pause to Reflect

As educators, it is always good to reflect on your own childhood.

- What were your favorite play spaces as a child?
- What did you enjoy doing?
- How might you incorporate some of your childhood play ideas into your setting?
- What role did the adults play when you were a child?
- What are your beliefs about play?
- How do you think play might have changed over the past forty years?
- What impact do you think this might have on children and the adults of the future?

👉 Important Things to Remember

- Free play is child-directed and internally motivated.
- Guided play includes adult involvement to extend the learning opportunities within the play.
- Early Childhood Educators emphasize that early childhood pedagogy should be child-centered, inquiry-based, and play-based.
- Young children's natural impulse is to learn by investigating what things are like and what they can make them do.
- The early childhood educator is responsible for offering children well-stocked play spaces where they can construct concepts and ideas, preferably in the company of friendly peers; designing daily routines that invite children to be active participants and to use emerging skills and concepts; supporting children's learning through interactions and conversations that prompt using language and ideas in new ways and that promote sharing meaning with others.
- Many learning opportunities occur spontaneously when the educator responds to an interest or need that a child expresses.

📌 Supplemental Readings

[CECE Practice Guideline: Pedagogical Practice](#)

[CECE Practice Note: Play-Based Learning](#)

[Follow the Leader: Child-led Play](#)

References

Danniels E & Pyle A. Defining Play-based Learning. In: Tremblay RE, Boivin M, Peters RDeV, eds. Pyle A, topic ed. Encyclopedia on Early Childhood Development [online]. Published February 2018.

Practice Note: Play-Based Learning, College of Early Childhood Educators, 2018

Practice Guideline: Pedagogical Practice, College of Early Childhood Educators, 2020

1.3: The Educator's Roles and Responsibilities in STEM is shared under a [CC BY-NC](#) license and was authored, remixed, and/or curated by Vicki Tanck (Northeast Wisconsin Technical College).

1.4: STEM Play Experiences Promote Learning

COURSE COMPETENCY 1. Explain the basic concepts of science, technology, engineering, and math (STEM)

Criteria 1.4 Explain how STEM experiences promote learning in all domains across a continuum.



The Value of Play

Young children's ways of learning require an approach to curriculum that allows them to build concepts and skills in integrated learning contexts. Such an approach supports children with analyzing a problem to discover a possible solution, experimenting with, and testing ideas, exchanging ideas with others, thinking creatively, cooperating with others to reach a goal, and focusing their attention and organizing their behavior as they play with others. These skills and dispositions work together to give children a foundation that enhances development and learning in all domains.

Early learning programs use numerous strategies to support children's play, such as observing and documenting, planning the learning environment, providing engaging and appropriately challenging materials, and being responsive to children's interest in engaging in play.

Through observations of children's play, teachers can deepen their appreciation of the value of play in early learning. For example, imaginary play is an important means of exploring ideas and social behavior and roles among preschool-age children. While older infants and toddlers engage in solitary imaginary play, such as feeding a stuffed animal or making a roaring sound while pushing a toy truck across the carpet, preschoolers engage with one or more peers in the more complex and elaborate form of imaginary play called "sociodramatic" play. In this type of play, children cooperate with one another to create a story and "script," assume various roles, figure out appropriate "costumes" and "props," and negotiate new ideas for play, such as, "I want to be a wolf, not a dog!"

Because imaginary play holds such rich potential for promoting children's cognitive, linguistic, social, and physical development, high-quality early learning programs recognize play as a key element of the curriculum. Children's spontaneous play is a window into their ideas and feelings about the world. As such, it is a rich source of ideas for curriculum planning (Lockett 2004). For example, if a teacher observes a group of children repeatedly engaging in imaginary play about illness or hospitalization, she or he might decide to convert the playhouse area into a veterinary clinic, adding materials to stretch their play. The educator might also read children stories involving doctors, hospitals, getting sick, and getting well. The educator's observations of children's resulting conversations and activities would suggest ways to deepen or extend the curriculum further. In thinking of ways to extend the curriculum, it will be important that teachers ensure that the materials used, and themes built upon are culturally familiar to the children and value children's cultural heritage.

While involved in play, children are challenged to meet the language, problem-solving, and social competencies of their peers. When play is interesting and important to children, they are eager to learn new vocabulary, new physical skills, and new social behaviors that will allow them to stay engaged in play (Jones and Reynolds 2011). Many three-year-old children, for example, have not yet mastered socially appropriate ways to enter other children's play.

Coaching by a sensitive, observant teacher on appropriate language for asking to join play can help a child overcome this hurdle, thereby opening a new area for learning.

When educators regularly observe and document brief, subtle moments of children's learning through play, those records can help families understand how useful and important play is in helping children to learn and grow. For example, a teacher might report a child's language and social development to the parent of a three-year-old: "I watched Sarah standing outside the playhouse area today. Instead of just watching the other children or wandering through their play without getting involved as she often does, she brought the children a book to read to the 'baby' in the family. They asked her if she wanted to be the big sister, and she said yes and joined right in. I have been thinking about ways to help her learn how to use her language to get involved in play with other children, but she figured out her own, creative way to join them."

During the early years, children grow markedly in their knowledge and skills in all areas of development. The dramatic increase in their emotional, social, cognitive, and language knowledge and skills occur hand in hand with the development of key areas of the brain, particularly the prefrontal cortex and its connections with the limbic system. Children are naturally curious and driven to learn about the way the world works and often develop and test hypotheses through observation and experimentation. Children's learning and development in all domains progress well when they are provided with appropriately challenging opportunities for play and exploration, with the support of skilled teachers who scaffold learning experiences.

What Children Learn Through Play

Just like the "whole child" is often broken down into developmental domains for studying, so too is learning. Many aspects of learning occur simultaneously; it is integrated and connected. To define learning we often break it into categories. Because the connection between play and learning is so important, the way it is broken down exists in many forms. Table 1.4.1 is a compilation of skills tying development into learning.

Table 1.4.1 What Children Learn Through Play

Domain	How it is Tied to Learning
Physical	• Personal care (hygiene, feeding, dressing,) • Nutrition • Safety • Motor (Movement) Skills ◦ Active physical play ◦ Perceptual motor (senses, effort, direction,) ◦ Gross (large) motor (running, throwing, ...) ◦ Fine (small) motor (hands, fingers, feet, toes)
Cognitive	• Cognitive approaches to learning and self-regulation ◦ Maintain attention ◦ Self-comfort ◦ Curiosity and initiative ◦ Self-control of feelings and behavior ◦ Engagement and persistence • Skills of inquiry ◦ Observe, investigate, document, communicate • Knowledge of the natural/physical world ◦ Understanding properties and events • Cause and effect ◦ Understanding relationship between cause/effect • Classification ◦ Learning the attributes of objects by exploring ◦ Compare, match, sort, categorize ◦ Finding similarities and differences ◦ Symbol • Number ◦ Understanding quantity (amount, degree) ◦ Assigning a numerical symbol to quantity ◦ Counting • Measurement ◦ Awareness of difference in properties ◦ (Size, length, weight, capacity, volume) ◦ Seriation (order 3 or more by comparison) ◦ (small/medium/large, loud/louder/loudest) ◦ Time (sequence of events, rhythm, yesterday/ tomorrow) • Patterning ◦ Recognize, reproduce, repeating sequences • Spatial relationships ◦ Experience an object's position in relation to others
Language	• Symbol/symbolic reasoning ◦ Sounds and letters are put together to represent things • Receptive language ◦ Listening, understanding, responding • Expressive language ◦ Speaking, communicating, conversation • Graphic (written) language/literacy ◦ Interest in print & books, phonology, pre-reading, reading ◦ Symbol, letter, print knowledge, pre-writing, writing

Domain	How it is Tied to Learning
Social	• Skills learning with adults ◦ Can stay at school without parent ◦ Can respond/enjoy adults other than parents ◦ Adults will help in times of need ◦ Adult will not always solve problems • Skills learned with peers ◦ Different approaches work for different peers ◦ Cooperation and turn taking ◦ Lead and follow ◦ Sustain relationships and helping peers ◦ Share materials, equipment, people, ideas ◦ Asserting rights and self defense ◦ Negotiating skills and solving conflicts ◦ Anticipate and avoid problems ◦ Realistic expectations and valuing differences • Skills learning in a group ◦ Respect ◦ Responsibility ◦ Compassion ◦ Tolerance ◦ Group identity ◦ Follow and adapt to routines and expectations ◦ How to enter and exit situations ◦ Deal with delay of gratification (patience) • Skills learned as an individual ◦ Self-help and self-care ◦ Make choices and initiate own activities ◦ Cope with rejection, hurt feelings, disappointment ◦ Take responsibility
Emotional	• Ability to deal with feelings ◦ Notice, label, and accept feelings ◦ Express feelings in appropriate ways ◦ Deal with the feelings of others ◦ Resolve inner fears, conflicts • Ability to exercise judgment ◦ Notice, label, and make choices ◦ Think through consequences ◦ Evaluate the effectiveness of choices ◦ Learn to take another viewpoint • Enjoying oneself and one's power ◦ Acquire a sense of self ◦ Develop self-confidence and self-esteem ◦ Build trust in self and others ◦ Reveal own personality ◦ Learn to take risks & learn from mistakes ◦ Become competent in several areas
Creative	• Flexibility (shifting from 1 idea to another) • Fluency (producing many ideas) • Sensitivity (awareness (moods, textures, senses,)) • Imagination / Originality

Domain	How it is Tied to Learning
	• Risk Taking / Elaboration (pushing boundaries) • Self as a resource (awareness, confidence in ability) • Experience (to build proficiency to build upon) • Visual and Performing Arts



Figure 5: Play is active learning (Image by [Hai Nguyen Tien](#) from [Pixabay](#))

? Indigenous Perspective



Figure 5 Indigenous Infant and a cradleboard (Image provided by author)

The Oneida Nation, like many Indigenous communities, traditionally used cradleboards as a tool to foster a child's development in various ways. Here are some of the ways in which cradleboards were and are still used within the Oneida community:

1. **Physical Development:** Cradleboards provide a secure and supportive environment for infants, promoting healthy physical development. The board's design helps keep the baby in a safe position, preventing injuries and promoting proper spinal alignment.
2. **Bonding and Attachment:** The close contact between the baby and the caregiver while in the cradleboard fosters a strong bond and attachment relationship. This is crucial for the child's emotional development and sense of security.
3. **Cultural Connection:** Cradleboards are often adorned with traditional symbols, patterns, and materials that reflect the Oneida culture. By using cradleboards, parents and caregivers pass on cultural values, stories, and traditions to the child from a young age, promoting a sense of identity and belonging.
4. **Mobility and Exploration:** While in the cradleboard, infants can observe their surroundings and participate in daily activities with their caregivers. This exposure to the environment allows for sensory stimulation, curiosity, and early learning experiences.

5. **Transition to Independence:** As the child grows, the use of the cradleboard can gradually transition into other forms of carrying or mobility, such as using a traditional baby carrier or learning to crawl and walk. This gradual transition supports the child's development of motor skills and independence.
6. **Safety and Comfort:** Cradleboards are designed to provide a safe and comfortable space for infants, especially during travel or outdoor activities. They offer protection from weather elements and can be easily carried by caregivers.

Overall, cradleboards play a multifaceted role in fostering a child's development within the Oneida Nation, encompassing physical safety, emotional bonding, cultural connection, and early learning experiences.

(OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>)

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CHAPTER OVERVIEW

2: Incorporate STEM into Your Daily Schedule

2.1: Transitions

2.2: Routines

2.3: Temporal Environment - The Daily Schedule

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2.1: Transitions

COURSE COMPETENCY 2. Incorporate STEM into Daily Routines

Criteria 2.1 Incorporate STEM opportunities into transitions.



There are many parts to a preschool day. The daily schedule includes routine activities and transitions between those activities. We will explore transitions and routines as well as how to create an effective schedule all while incorporating STEM learning throughout all daily routines. Let's start by taking a look at transitions.

Transitions

It is important to focus on creating and managing smooth transitions between activities in the classroom. Reasons to address transitions between activities in early childhood classrooms include:

Transitions take up a great deal of time in preschool classrooms. During transitions, children often spend a lot of time waiting (e.g., waiting until everyone has finished their snack, waiting for everyone to clean up before beginning large group time). All of this time waiting with nothing to do can lead to unrealistic expectations and challenging behaviors.

Some children (and adults) have stressful and frustrating experiences during transitions between activities (e.g., children arguing over who

took out what toys and who should put them away; children not knowing where to put certain toys when they are done with them; children not knowing what to do, children not knowing expectations for the transition).

- Many preschool teachers and other caregivers consider children's ability to independently make transitions between activities one of the essential skills needed in group contexts such as preschool and kindergarten.[11]

Supporting Successful Transitions

There are numerous strategies that can be used to ensure well-organized transitions between activities. These include strategies you use before the transition, during the transition, and following the transition.

• Before the Transition

- Plan your daily schedule to include the minimal number of transitions that occur over the course of the day. Minimize the number of transitions in which all children have to do the same thing at the same time (e.g., Do all children have to go to the restroom at the same time? Can some children come over to the rug and sing a song or read a book, while other children finish an activity?).
- Plan for what adults will do during transition times (e.g., Which adult is responsible for greeting the children? Who will begin looking at books on the carpet with children?).
- Teach children the expectations for the transition routine. Teaching children how to clean up and how to line up will reduce the length of transition times. By reducing transition times, more time is available for children to spend in other learning activities. As children become familiar with the expectations, problem behaviors are less likely to occur.
- Provide verbal and nonverbal cues before transitions (e.g., "Five minutes 'til snack. It's almost time for clean-up," show pictures of the next activity, beat a drum). Once a transition cue has been established, the cue should be used consistently to signal the transition.

• During the Transition

- Engage children in transition activities (sing songs, play word or guessing games, recite rhymes, organize finger plays). Transition activities provide children with an activity to complete while other children are still transitioning. These activities also encourage children to finish their previous task, so that they can play the game or sing the song. During these activities, skills related to the transition can also be taught (e.g., setting the table for snack or lunch, sorting toys during clean-up time).

- Allow children adequate time to finish projects or activities so they do not become frustrated by activities ending too soon. Give them a warning that it is about time to change activities.
- Plan something to engage those children who finish an activity quickly, so they are not waiting without anything to do (e.g., if some children finish cleaning up and getting to large group quickly, they might look at books while waiting for other children to finish cleaning up).
- Individualize support to accommodate individual children's needs.
 - Photos to help anticipate what activity is next.
 - Directions given in a child's home language or sign language.
 - An individual warning to a child that it will soon be time to clean up and begin a new activity.
- **Support May Need to be Individualized** (i.e., one child may need an adult to provide a five-minute, three-minute, and one-minute warning before clean up while the rest of the class might need only a three-minute warning).
- **After Transitions**
 - Provide positive attention and feedback to children following transitions.
 - When children pick up toys without much prompting, share with them how this shows how well they take care of the classroom materials.
 - When children are working together to accomplish the task more quickly, let them know how much you appreciate their teamwork (e.g., "Nicholas and Jorge did a great job cleaning together and moving to the carpet").

You can also work to promote independence during transitions by

- Allowing children to move individually from one area to another area when they complete an activity (e.g., as children finish snack, they are encouraged to go to the carpet and choose a book; as children finish putting away their coats and backpacks, they are encouraged to get a puzzle).
- Teaching children to help others (e.g., have children move as partners from one activity to another, or ask one child to help another child gather his/her backpack).
- Helping children self-monitor during transitions (e.g., children can be asked to think about how quietly or quickly they moved from one activity to another).

Read and compare the two vignettes below of a teacher using a dismissal transition. The first will show you a more traditional example of a dismissal transition from circle time to handwashing before lunch. The second will demonstrate how a teacher might incorporate STEM into a transition.

In vignette number 1, we will see a teacher use the children's interest in their names and the names of their friends to create a dismissal ritual. In vignette number 2, we will see a vignette that focuses more explicitly on STEM learning during the dismissal transition.

Vignette

Example 1

Ms. Cone had used the children's name tags in transition activities for quite some time, at first pointing out and naming the first letter in each name as she called children to go wash hands or to get their jackets before going outside. Somewhat later, she held up each of the nametags and pointed to the first letter as she asked the child to name it. Today, she is using the first sounds in names to send a few children at a time from the circle time area to wash hands for lunch: "If your name starts with /k/, you may go wash your hands. Yes, Connie and Carolina, you may go to the sink. Both of your names start with the /k/ sound." Cindy sees Connie and Carolina stand up, and she stands up too. Ms. Cone explains that Cindy begins with the /s/, not /k/ sound, and that she'll get a turn soon. Cindy says, "I'm a C too!" Ms. Cone says, "Oh, you are right. Your name begins with the letter c like Connie and Carolina, but it starts with a different sound. We hear /k/ at the beginning of Connie and Carolina—/k/ Connie, /k/ Carolina. We hear /s/ at the beginning of your name—/s/—Cindy. I'm going to say that sound next: 'If your name starts with /s/, you may go wash your hands.'" Sabrina stood up, joined hands with Cindy, and they walked to the sink together.

[12]

Example 2

Here's how we can modify the vignette to focus more explicitly on STEM learning during the dismissal transition from circle time to washing hands for lunch:

Ms. Rodriguez, the preschool teacher, had just finished a captivating circle-time discussion about the life cycle of plants. As she transitioned the children from the circle area to the handwashing station for lunch, she designed an activity that seamlessly integrated STEM concepts.

"Okay, little scientists," Ms. Rodriguez exclaimed with a smile, "let's use our observation skills as we move to wash our hands!"

As the children lined up, she distributed small magnifying glasses and encouraged them to explore the classroom environment. "Find something that's living and something that's non-living. How can you tell the difference?"

The children eagerly scanned the room, examining plants, toys, and classroom objects. Some spotted the potted plants by the window, while others investigated a plastic toy car.

Ms. Rodriguez guided their observations with thoughtful questions: "What do living things need to survive? How do they grow and change? Can you find any signs of growth or movement?"

Once everyone had made their observations, she led them to the sink area, where they continued the discussion while washing their hands. "Just like plants need sunlight and water to grow," she explained, "we need clean water to stay healthy and wash away germs!"

The children nodded, their faces lighting up with understanding. By incorporating STEM concepts into this simple transition, Ms. Rodriguez not only made the dismissal process engaging but also encouraged scientific thinking and exploration in everyday activities.

Built into example 1 is a dismissal ritual that takes full advantage of young children's interest in their names and the names of their friends. As part of this dismissal ritual, the teacher invites children to use their emerging skills in distinguishing the distinct sounds of language, described in the language and literacy foundations as phonological awareness. She embeds this learning in the context of a game, one that inspires children to listen carefully to the sounds spoken in instructions for inviting small groups of children to wash hands. The transition from large group to the sink area goes much more smoothly as a result, and in the process, children get to use an important emerging skill.

Example 2 helps the children use their emerging skills and knowledge about the needs of living things. The teacher carefully crafts her questions to help the children show what they learned in the previous lesson and she helps the children connect the learning to other areas of their lives such as handwashing to connect the needs of living things to a concept they already know, handwashing. Transitions can be used to help the teacher assess what the children learned during the lesson.

Example 2 was generated using OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>

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2.2: Routines

COURSE COMPETENCY 2. Incorporate STEM into Daily Routines

Criteria 2.1 Incorporate STEM opportunities into routines.

Routines and Rituals

Schedules define the whole day, whereas routines are more specific sets of regularly occurring behaviors. Routines provide some security and a sense of what comes next; children are able to anticipate what will happen, and thus feel more secure.

Daily routines and rituals also provide a second context for curriculum. They offer possibilities for children to use their emerging skills and to apply emerging concepts and ideas. Early childhood daily routines include arrivals and departures, mealtimes, naptimes, diapering, toileting, dressing, handwashing, tooth-brushing, and transitions between one place and another. They also include rituals such as sign-in sheets, health checks, waiting lists, attendance counts, dictated stories, reminder notes, or voting.

Children sit down for a meal, wash their hands, and put jackets and shoes on hundreds of times in order to provide excellent opportunities for children to use and build emerging skills and concepts. In group care, the care routines during arrivals, departures, meals, naps, diapering, toileting, and dressing provide excellent opportunities for children to use and challenge their emerging skills and concepts. When an infant whose diaper is about to be changed hears her teacher describe what it is she is about to do, the infant experiences a flood of words, which eventually become an anticipated phrase that gives meaning to a familiar experience. When this same infant hears a request to put his arm into the sleeve of a shirt, he is invited to demonstrate that he has understood this phrase and experiences the joy that comes with sharing meaning with the teacher. When a preschool child looks in anticipation each morning at the helper chart to see what job she gets to do that day, they are invited not only to cooperate in the care of the classroom, but also to build their emerging skills in understanding the meaning of print that accompanies the photo or drawing. Care routines are natural opportunities for children to engage in learning. Therefore, teachers plan the routines of care and the daily rituals that pepper the day in ways that invite children to be active participants and to use and build their emerging skills and concepts in meaningful situations.^[8]

A vignette featuring toddlers shows the kind of learning that occurs in another routine:

Vignette

Toddler Lunch-Time Routine

Four toddlers are seated at a low table for lunch. Their primary care teacher sits with them at the table. To his right, on a low bench, the primary care teacher has a bin that holds everything he needs for the meal. He pulls out bibs for each toddler and helps each toddler put one on. Each toddler finds a cube chair to sit in. The teacher puts an empty bowl in front of the toddler on his left. He offers this toddler a pair of small plastic tongs, holds a plate of small sandwiches, and asks, “Would you like to take a sandwich?” The toddler grabs the tongs and, after a few trials, manages to pick up one of the sandwiches and drop it onto his plate. Later, after each toddler has taken a sandwich, the teacher pulls from the bin a clear plastic measuring cup, on which a red line is drawn at the one-cup mark. He fills the measuring cup to the red line. He places an empty glass in front of a toddler and, offering the toddler the measuring cup, says, “Would you like to pour?” The toddler wraps his hand around the handle and tips the cup over his glass. He spills a bit at first, but adjusts his hand and manages to empty the measuring cup. He looks up at the teacher and smiles. The teacher smiles in response, saying, “You poured your milk, Stephan! You know how to do it!” The toddler seated next to Stephan reaches for the empty measuring cup. The teacher says, “And now you can pour milk into your glass, Alexi. I’ll put the milk in the measuring cup first.”^[9]

To incorporate STEM learning into the routine described in the vignette, you could add elements that encourage exploration and understanding of scientific concepts. Here are some suggestions:

1. ****Measurement and Volume****: Instead of using a clear plastic measuring cup with a red line, use different-sized containers with clear markings for volume. Have the toddlers compare the volume of different containers and discuss concepts like full, half-full, and empty.

2. **Materials and Properties**: Introduce different materials for the toddlers to explore during lunchtime, such as plastic, metal, and cloth. Encourage them to describe the properties of each material, like smooth, rough, soft, or hard.
3. **Simple Machines**: Integrate simple machines into the activity by using child-friendly versions of tools like levers (e.g., child-sized tongs), ramps (e.g., incline plates for sliding food), or wheels (e.g., rolling carts for serving).
4. **Food Science**: Discuss basic food science concepts, such as the states of matter (solid, liquid) and changes in food properties when cooked (e.g., bread becoming crispy when toasted).
5. **Mathematics**: Incorporate counting, sorting, and pattern recognition into the mealtime activities. For example, have the toddlers count the number of sandwiches on each plate or sort different types of food items based on color or shape.

By adding these STEM elements, you can enhance the toddlers' learning experience during mealtime and promote their curiosity about the world around them.

How to incorporate STEM into the lunchtime routine was generated using OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>

Preschool Sign-In Routine

Many preschool classrooms have children sign in when they arrive. This is a literacy-related activity as it involves letters and writing. It can even incorporate math if you count how many children are at school that day. However, STEM can be incorporated into this daily classroom routine in several ways. Teachers need to think about routines and be intentional in planning to incorporate STEM learning into parts of their day such as Sign-in. Read the example below to see how STEM can easily be integrated into one such routine.

Incorporating STEM into routines like sign-in sheets in a preschool setting can be both educational and engaging. Here are some ideas on how to do it:

1. **Interactive Sign-In**: Create an interactive sign-in board where children can use STEM-related elements. For example, instead of traditional names written on paper, use magnetic letters or blocks for children to spell their names. This promotes letter recognition, fine motor skills, and spatial awareness.
2. **Graphing Attendance**: Use the sign-in data to create simple graphs or charts. For example, tally how many children are present each day and represent this information using bar graphs or pictographs. Discuss the concepts of counting, comparing quantities, and interpreting data.
3. **Technology Integration**: Incorporate technology by using a digital sign-in system where children can tap their names on a touchscreen or use a digital pen to sign in. This introduces children to basic technology skills and reinforces the connection between STEM and everyday tasks.
4. **Mathematical Patterns**: Design the sign-in sheet to include patterns or sequences for children to follow. For instance, they may need to fill in missing numbers or complete a pattern of shapes or colors. This encourages critical thinking and mathematical reasoning.
5. **Sensorial Sign-In**: Integrate sensory elements into the sign-in process. For example, use textured materials like sandpaper or fabric for children to trace their names, promoting tactile exploration and sensory awareness.
6. **STEM-themed Sign-In Questions**: Include STEM-related questions on the sign-in sheet that children can answer or discuss with teachers. For instance, "What is your favorite animal and why?" or "Can you name a plant you saw outside today?" This encourages scientific thinking and vocabulary development.
7. **Problem-Solving Challenges**: Incorporate problem-solving challenges into the sign-in activity. For example, provide a set of building blocks and ask children to create a structure that represents something they learned recently. This fosters creativity, engineering skills, and communication.

By infusing STEM concepts into sign-in routines, preschool teachers can create meaningful learning experiences that connect everyday tasks with foundational STEM skills, fostering a love for inquiry and exploration in young children.

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2.3: Temporal Environment - The Daily Schedule

COURSE COMPETENCY 2. Incorporate STEM into Daily Routines

Criteria 2.3 Incorporate STEM opportunities into daily schedule.

The Daily Schedule

One feature of a well-organized classroom is the use of a schedule and established routines. Schedules and established routines are important because they influence a child's social and emotional development. While referred to as the daily schedule, it is important to recognize that the flow, or the predictable order of the day, should be the focus (rather than abiding by rigid timelines for the different parts of the day). While there may be parts of the day that are at fixed times (for example meals or using a shared outdoor space), teachers should use flexibility to make the schedule meet the needs of the children. If an activity seems to be coming to a natural conclusion earlier, consider transitioning to the next part of the day. If children are really engaged in an activity, consider giving them additional time to wrap up their exploration. Flexibility also comes in handy when there are changes that affect the schedule that are beyond your control, such as bad weather preventing outdoor play.^[1]

Why Have a Daily Schedule?

Schedules are important because they

- Help children know what to expect:
 - Schedules and routines help children understand the expectations of the classroom environment—which may be very different than in other settings.
 - Knowing expectations may lower behavior problems.
- Enhance feelings of security:
 - Predictable and consistent schedules in preschool classrooms help children feel secure and comfortable.
 - Those children who have difficulty with change especially need to feel secure.
 - Children who do not yet speak and understand English well also benefit from predictable and consistent classroom schedules and routines.
- Influence a child's cognitive and social development:
 - When periods of play are longer, children engage in more complex social and cognitive play.
- Increase child engagement rates:
 - Child engagement is defined as the amount of time a child spends interacting with his or her environment (adults, peers, or materials) in a developmentally and contextually appropriate manner, at different levels of competence.
 - Schedules that give children choices, balanced activities, planned activities, and individual activities result in a higher level of engagement.

Several factors influence child engagement.

- Attention span of children:
 - Plan activities to maximize children's engagement:
 - Use other adults to assist.
 - Use novel materials.
 - Limit duration to ensure children stay engaged throughout the activity.
- Alertness level:
 - Plan activities that require more child attention and listening skills during times when children are more alert.
 - Plan calming activities after active activities.
 - Note if some children may be tired or sick.
- Adult availability:

- For a more active part of your day, you may want to have more adults to support the children’s learning and the management of the classroom.
- Time for children’s needs—allow enough time for children to fully engage and benefit from an activity. When children engage in longer periods of play they:
 - Show higher levels of exploration, experimentation, and persistence.
 - Utilize materials in more creative ways.
 - Develop social relationships.[2]

Creating the Daily Schedule

The first component is “blocks of time,” the big chunks of time set aside for classroom activities. Preschool schedules typically include:

- Large group or circle time
- Child-initiated play time
- Snack time and meals
- Outdoor time
- Rest time

The next component is the sequence. Sequencing the blocks of time requires taking into consideration multiple factors including:

- Method of arrival/departure (bus or transportation provided by families)
- Schedules of other classrooms (e.g., which classroom goes outdoors at what times?)

Schedules include some of the daily routines such as meal times, but may not include others such as bathroom breaks or clean up routines.



Figure 2.1: This is a visual schedule that shows children images of the different parts of their day.[3]



Figure 2.2: Here is a schedule that combines visual cues, written times, and text descriptions.[4]

Finding Balance in the Schedule

When planning the schedule you want to provide balance. This includes:

- Alternating active with quiet activities to help children with self-control.
- Having a mix of small group and large group activities.
- Having activities that differ in noise level, pace, person leading (child vs. adult), and location (indoor vs. outdoor).

- Having a mix of teacher-guided and child-initiated activities.[5]

Child-Initiated Play and Teacher-Guided Activities

The daily schedule balances child-initiated play and teacher-guided activities. The latter involves teachers planning, introducing, and guiding specific activities to enhance children's learning during small- and large-group times. In contrast, child-initiated play refers to children's responses to ideas and materials introduced by teachers that the children are free to explore without teacher guidance. Child-initiated play also includes those times when children create, organize, and engage in activities completely on their own.

A daily schedule that ensures ample time for children to initiate their own play in well-developed interest areas is critical to the teaching and learning. Young children need ample time to engage in play, in the company of peers, in order to build their ideas, to pose problems, to try out solutions, and to negotiate and exchange ideas. When children initiate, organize, and develop their own play in the interest areas, it is called child-initiated learning. At times, children choose to play alone, but frequently, child-initiated play takes place in small groups of their own choosing.

In a schedule with ample time for children to initiate play in well-stocked interest areas, there are times when teachers organize and guide specific activities for children. Such teacher-guided curriculum activities are clearly distinct from child-initiated curriculum activities. Teacher-guided activities occur in two contexts—small groups and large groups. A small group would consist of one teacher working with a group of four to eight children. A large group is typically a gathering of all the children in an early childhood setting. Each context serves a different purpose and requires different preparation and different teaching strategies.

For some aspects of the curriculum, teachers may choose to organize an activity with a small group of children. Although initiated and guided by the teacher, an effective small-group encounter of this nature should still be rich in possibilities for children to contribute and negotiate ideas with each other. Teacher-guided activities in small groups work best in quiet spaces away from distractions of the full group and provide a manageable context for children to discuss and explore ideas and experiences. The teacher listens to children's ideas, helps orchestrate the give-and-take of ideas among children, and poses ideas or problems for children to wonder about, explore together, or even solve. Away from the distractions of a large group, teachers can easily observe, listen, and converse with children in a small group, as well as note how individual children think, express ideas, relate with others, and use their emerging skills.

Such teacher-guided conversations can enrich children's learning in all domains, particularly the children's language and vocabulary development. In addition, teachers can intentionally guide the development of specific skills by planning small-group activities (e.g., songs, games, shared reading) for short periods of time that playfully engage children in using specific emerging skills.

Small-group activities have several advantages over large-group activities. With small groups of children, teachers can readily observe, listen, and document children's developmental progress. Teachers can also individualize the curriculum and use questions or prompts to scaffold each child's thinking in more complex ways.

Whether the activities are child-initiated or teacher-guided, children's use of materials in interest areas provide teachers with excellent opportunities to observe how they build concepts and skills and how they negotiate ideas with others. Moments of observed play and interactions also provide teachers with ideas on how to extend children's exploration and learning through future encounters with related materials that add novelty, challenge, and complexity in each domain.

Large groups provide another context for teacher-guided activities. The large group—typically a gathering of the entire class—works well for singing, acting out songs and stories, playing games, sharing experiences with each other, telling stories, building a sense of community, and organizing the daily schedule and activities. Storytelling is one of the more popular large-group experiences, one that has rich potential for adding to children's understanding about the world around them. Storytelling allows teachers, children, family members, as well as storytellers from the community to tap into and build children's knowledge and experiences in meaningful ways. Large-group time is also when teachers let the whole group of children know what new experiences will be available in the interest areas or what will happen in small groups that day. Large-group gatherings that occur at the end of the day provide opportunities to review noteworthy happenings and to anticipate what will be available the next day.[6]

Here are some examples of daily schedules for preschool classrooms.

Table 2.1: Half-Day Program Sample

Time of Day	Routine/Activity	Description
8:00	Arrival/Greetings	Wash Hands, Sign-in, Get Name tags
8:05-8:20	Group Time	Welcome, Songs, Stories, Discussions
8:20-9:30	Open Choice Time Outdoors	Explore classroom areas
9:30	Clean-up	Wash Hands, transition to indoors
9:35-10:45	Snack/Open Choice Indoors	
10:45	Clean-up	
10:50-11	Closing Circle	

Table 2.2: Full Day Program Sample Daily Schedule[7]

Time of Day	Routine/Activity	Description
8:00	Arrival/Greetings	Wash Hands, Sign-in, Get Name tags
8:05-8:20	Group Time	Welcome, Songs, Stories, Discussions
8:20-9:30	Open Choice Time Outdoors	Explore classroom areas
9:30	Clean-up	Wash Hands, transition to indoors
9:35-11:00	Snack/Open Choice Indoors	
11:00	Clean-up	
11:10-11:25	Story Time	Transition to wash hands for lunch
11:30-11:50	Lunch	
11:50	Explore books on rest Mats	
12:10-2:00	Rest Time	
2:00-3:15	Indoor Choice Time/Snack	
3:15	Clean-up	
3:20	Large Group Circle	Games, Songs, Stories
3:40	Explore Outdoors	
5:00	Clean-up	
5:05	Indoor Small Group/Choice Centers	Fewer areas open

Incorporating STEM into the Daily Schedule

So far in this chapter, you have reviewed the importance of a daily schedule and factors to consider when creating your daily schedule. Below you will explore how to incorporate STEM into your daily schedule.

Incorporating STEM (Science, Technology, Engineering, and Mathematics) into the daily schedule in preschool can be done in various creative and engaging ways. Here are some ideas:

1. ****Morning Circle Time:****

- ****STEM Question of the Day:**** Start the day with a STEM-related question or problem for children to discuss. For example, "How can we make a paper airplane fly farther?" This encourages critical thinking and problem-solving skills.

- **Science Demonstrations:** Conduct simple science demonstrations or experiments during circle time, such as mixing colors, exploring magnets, or observing plant growth. Discuss the scientific concepts behind these activities.

2. **Learning Centers:**

- **STEM Learning Stations:** Set up dedicated STEM learning stations within learning centers. For example, a building block station for engineering, a sensory table for exploring materials, a math manipulative area, and a technology station with age-appropriate educational apps or activities.
- **Problem-Solving Challenges:** Introduce STEM-themed problem-solving challenges at learning centers. For instance, challenge children to build a bridge using blocks or create a structure that can withstand a "wind" (fan) test.

3. **Outdoor Play:**

- **Nature Exploration:** Encourage children to explore nature during outdoor play. Provide magnifying glasses, binoculars, and observation tools for them to investigate insects, plants, and outdoor elements. Discuss scientific observations and encourage curiosity.
- **Engineering Play:** Incorporate outdoor engineering activities such as building with natural materials (sticks, rocks) or creating pathways for water flow using simple materials like tubes or gutter sections.

4. **Art and Creativity:**

- **STEAM Art Projects:** Combine STEM with art (STEAM) by integrating science or math concepts into creative projects. For example, create geometric shape collages, explore color mixing through painting, or design structures using recycled materials.
- **Coding with Art:** Introduce basic coding concepts through art activities. Use coding apps that allow children to create art by programming sequences of colors or shapes.

5. **Literacy Integration:**

- **STEM Storybooks:** Use storybooks that introduce STEM concepts as part of literacy activities. After reading, engage children in discussions or activities related to the story's STEM themes.
- **Writing about Science:** Encourage children to write or draw about their scientific observations, experiments, or engineering designs in journals or on interactive whiteboards.

6. **Meatime Activities:**

- **Food Science:** Incorporate food-related STEM activities during snack or mealtime. For example, discuss the science of cooking, explore how ingredients change form (solid to liquid), or conduct simple food experiments (e.g., sinking vs. floating).
- **Nutrition Education:** Teach children about healthy eating habits, the importance of balanced diets, and how food provides energy for our bodies. Use visuals and hands-on activities to reinforce these concepts.

7. **Music and Movement:**

- **STEM Songs:** Sing songs related to STEM themes, such as counting songs, songs about shapes or colors, or songs that introduce scientific concepts (e.g., weather songs, animal habitats).
- **Rhythmic Math:** Incorporate math concepts into movement activities, such as counting steps, creating patterns with movements, or exploring concepts like fast/slow or high/low through music and movement.

8. **Technology Integration:**

- **Educational Apps and Tools:** Use age-appropriate educational apps, interactive whiteboards, or coding tools to introduce technology skills and concepts like sequencing, problem-solving, and logical thinking.
- **Digital Storytelling:** Create digital stories or presentations about STEM topics that children can contribute to, fostering creativity and digital literacy skills.

By integrating STEM into the daily schedule, preschool teachers can provide rich, hands-on learning experiences that promote curiosity, critical thinking, and a strong foundation in STEM disciplines from an early age.

How to incorporate STEM into the daily schedule was generated using OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>

References

[1] *Guide to Managing the Classrooms: Schedules and Routines* by the U.S. Department of Health and Human Services is in the public domain;

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[5] [Guide to Managing the Classrooms: Schedules and Routines](#) by the [U.S. Department of Health and Human Services](#) is in the public domain

[6] [California Preschool Curriculum Framework, Volume 3](#) by the [California Department of Education](#) is used with permission

[7] Based on the College of the Canyons Early Childhood Education Sample schedule

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CHAPTER OVERVIEW

3: STEM Experiences and Environment

3.1: The Learning Environment

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3.1: The Learning Environment

Course Competency 3. Establish a developmentally appropriate environment for STEM.

Criteria:

- 3.1. explain how the environment supports children's physical development.
- 3.2. explain how the environment supports children's social/emotional development.
- 3.3. explain how the environment supports children's language development.
- 3.4. explain how the environment supports children's approaches to learning.
- 3.5. explain how the environment supports children's cognitive development

Supporting Learning in All Domains

As you have learned in other courses the domains of development are interrelated. Development in one domain impacts development in the others. Chapter 3 will not be divided into separate sections for each domain or for each criterion for Course Competency 3 because of the interrelatedness of developmental domains. As you read this chapter, keep in mind how the domains are interrelated and how development in one domain affects the others. Also, consider how learning and development specific to STEM experiences support learning in all domains.

The indoor and outdoor environments provide the context for children's physical and social explorations and construction of STEM concepts. The following are strategies for helping educators set up a physical environment that is rich, stimulating, and conducive to children's construction of knowledge. As you read each example think about how the materials and activities the teacher provides help foster learning and development in each developmental domain. (physical, social-emotional, cognitive, language, approaches to learning)

- Be thoughtful about what objects and materials to include in the environment.
- Provide a variety of natural materials to observe and investigate.
- Include objects and materials that allow for creativity and open-ended investigation.
- Include living things in the preschool environment.
- Include scientific tools for observation, measurement, and documentation.
- Make scientific tools available throughout the preschool environment.
- Consider adaptations in scientific tools and materials for children with special needs.
- Use technology to support children's scientific experiences.
- Present documentation of science-related experiences in the preschool environment.
- Include children's books with STEM-related content.
- Use the outdoors for natural explorations and investigations.
- Organize the space in ways that promote children's explorations.
- Allow space for observations and for objects, materials, tools, and resources related to science, technology, engineering, and math.
- Allow flexibility in the use of physical space and furniture to accommodate each activity's changing needs.
- To promote self-direction and free exploration, tools, and materials need to be accessible and consistently available to children.
- Social interactions are necessary for conceptual growth and the development of communication skills.
- Always be aware of children's safety.
- Foster children's curiosity and questioning.

- Guide children in exploring their questions.
- Be an active observer.
- Talk with children and engage them in conversations during their investigations.
- Provide children with time.
- Know when to intervene and when to stand back.
- Model and integrate the use of STEM vocabulary.

Setting the Stage for Play Environments

The environment is often labeled as a “teacher” in Early Childhood Education. The meaning behind this label is that if an environment is intentionally created with developmentally appropriate practice in mind, it will serve to assist with learning as well as classroom management. A quality early childhood educational environment, whether it is indoor, outdoor or temporal (timing, sequence, and length of activities and routines), should encourage engagement, stimulate learning, and promote growth in all areas of development.

The effective preschool teacher recognizes, understands, and respects the values of children’s families and communities and attempts to make the preschool environment as congruent with those values as possible.[1]

Creating an Environment for Social and Emotional Learning

Teachers in a high-quality preschool program ensure that all the children feel safe and nurtured. They know how to create a classroom climate of cooperation, mutual respect, and tolerance and support children in developing skills needed to solve problems and resolve conflicts with peers. Social and emotional learning is central to young children’s development in the preschool years and works hand in hand with cognitive and academic learning. To learn well, they need to feel safe, to feel comfortable with their preschool teacher, and to be supported in their play with other children. All these factors interact with each other and either promote or detract from children’s learning and well-being. Because preschool children are naturally curious and learn best in meaningful contexts, teachers responsible for planning the learning environment and curriculum will best support children’s learning and development when they use a variety of strategies to support children’s learning—such as focusing on interactions, scaffolding learning experiences, engaging in explicit instruction, changing the environment and materials, and making adaptations to the learning environment.

Teachers make use of daily routines as an important context for learning, integrating engaging learning opportunities into the everyday routines of arrivals, departures, mealtimes, naptimes, hand- washing, setup, and cleanup, both indoors and outdoors. Children enthusiastically practice and apply emerging skills when they are helpers who ring the bell to signal it is time to come inside; when they count how many are ready for lunch; when they move a card with a child’s photo and name from the “home” column to the “preschool” column of a chart near the room entry; when they put their name on a waiting list to paint at the easel; or when they help set the table for a meal, making sure that each place has a plate, utensils, and a cup. Such routines offer opportunities for children to build language skills, to learn the rituals of sharing time with others, and to relate one action in a sequence to another” (adapted from CDE 2010, 18).



Figure 5.2: This young girl is learning through the daily routine of setting the table.[2]

Based on teachers’ assessments of individual children’s learning, the teachers might add materials to play-based interest areas, decide to read books with small or large groups, adapt activities to meet the diverse learning needs of children in the classroom, and

think of a particular topic area that children would be interested in investigating. Guided by the Wisconsin Model Early Learning Standards, teachers use their understanding of children's learning and development as a way to ensure they adequately support children's development across all domains. With clear ideas or objectives in mind, teachers plan curriculum that includes strategies to enhance the learning of all children in a group, as well as strategies to support the learning of individual children.

Teacher Tip

Reflecting the Interests and Skills of the Children

During an annual ECE conference, a presenter challenged the participants to change their thinking on student readiness. As a teacher, I spent a lot of time considering how to best prepare the children in my care for the transition to older classrooms. Attending this workshop inspired me to think differently. Readiness is not about getting children ready, but rather getting our environments ready for the children as they come to us. To put this into practice, our preschool teachers visited children in the toddler classrooms and observed the interest in specific areas, materials and took notes on skills observed. As the children began to transition into our preschool classroom the room was set with a mixture of materials they were familiar with as well as new materials appropriate for their new stage of development. The pressure was off of the toddler teachers to prep for what they thought the children needed to be ready with and the new preschool teachers had realistic expectations of the children as they matriculated into their new environments. We took this idea one step further with our older preschoolers and had them help us to create the spaces they wanted to use. The children walked from area to area and estimated how many children could safely exist in each area. Next, we placed the number of students allowed in each area at a time (from the children's perspective) and we let them experiment. We reflected with the children our observations and their experiences and decided together if the amount of children allotted per area was reasonable or needed adjusting. We found that by incorporating the children's ideas and participation in environmental design, they were more respectful of the environment and the environment reflected their ideas and values. Remember: Not every area of the classroom has to be created equal. The environment should reflect the interests and skills of the people who use it.^[5]

To ensure that the STEM environment in the preschool classroom reflects the interests and skills of the children in the classroom, teachers can implement several key strategies:

1. ****Observation and Assessment:****

- Regularly observe and assess children's interests, strengths, and areas of curiosity related to STEM. Pay attention to their natural inclinations, questions they ask, and activities they engage in with enthusiasm.

2. ****Child-Centered Design:****

- Design the STEM environment with children's interests and skills in mind. Offer a variety of materials, tools, and activities that align with their interests and cater to different learning styles.
- Allow children to have choices and autonomy in selecting STEM activities. Provide opportunities for them to lead and explore topics that fascinate them.

3. ****Flexible Learning Spaces:****

- Create flexible learning spaces that can be adapted to different STEM activities and projects. Designate areas for hands-on exploration, quiet observation, collaborative work, and independent investigation.
- Use movable furniture, storage solutions, and open-ended materials that can be easily reorganized to support diverse interests and activities.

4. ****Incorporate Diversity and Inclusion:****

- Ensure that the STEM environment reflects diversity in terms of cultures, backgrounds, experiences, and abilities. Use materials, books, and resources that represent a range of perspectives and promote inclusivity.
- Encourage collaborative learning and peer interactions that celebrate differences and encourage empathy, respect, and understanding among children.

5. ****Personalized Learning Experiences:****

- Offer personalized learning experiences based on children's interests and skills. Provide opportunities for deeper exploration of topics they are passionate about and scaffold learning to meet individual needs.

- Incorporate open-ended projects and challenges that allow children to apply their knowledge, creativity, and problem-solving skills in meaningful ways.

6. ****Parent and Community Involvement:****

- Engage parents and families in the STEM learning environment by sharing information about children's interests, showcasing their work and accomplishments, and inviting them to participate in STEM-related activities.
- Collaborate with local experts, professionals, and community resources to bring diverse perspectives, real-world experiences, and career exploration opportunities into the STEM environment.

7. ****Reflection and Feedback:****

- Regularly reflect on the effectiveness of the STEM environment in meeting the interests and needs of children. Gather feedback from children, families, and colleagues to make ongoing improvements and adjustments.
- Use documentation and assessment tools to track children's progress, interests, and skills related to STEM. Use this information to inform planning and decision-making in the STEM environment.

By adopting these strategies, preschools can create a dynamic and inclusive STEM environment that empowers children to explore, discover, and thrive based on their unique interests, talents, and abilities.

How to incorporate the interests and skills of the children into the STEM environment was generated using OpenAI. (2024). ChatGPT (3.5) [Large language model]. <https://chat.openai.com>

Early childhood teachers see and support children as scientists and thus design the play environment to serve the children's inquisitive minds. Teachers also provide the materials children need to construct concepts and ideas and master skills in the natural context of play. Children learn from opportunities to discover materials that they may be seeing for the first time and need time to explore and get to know the properties of these materials. It means offering children materials that they can organize into relationships of size, shape, number, or function and time. Children can investigate what happens when they put these materials together or arrange them in new ways, experiencing the delight of discovering possibilities for building with them, transforming them, or using them to represent an experience.

Loose Parts

Loose Parts can be used in the indoor or outdoor environment. Children can build and create with these in many ways.

An article by Reading Play discusses Loose Parts Theory:

'Loose parts' theory is about remembering that the best play comes from things that allow children to play in many different ways and on many different levels. Environments that include 'loose parts' are infinitely more open-ended, stimulating, and engaging than static ones. The play environment needs to promote and support imaginative play through the provision of 'loose parts' in a way that doesn't direct play and play opportunities, but allows children to develop their own ideas and explore their world.

- Must be included in both indoor and outdoor environments
- Have no defined use and play workers must support the children when they decide to change the shape or use of them.
- Must be accessible physically and stored where they can be reached by children without having to ask the play workers. The children should know that they can use them whenever and however they wish.
- Must be regularly replenished, changed, and added to.[6]

See: <https://extension.psu.edu/programs/b...does-this-mean> for more information about Loose Parts

Early childhood teachers also design the daily routines as rich opportunities for children to participate actively and to use their emerging skills and ideas in meaningful situations. Equally important are the ways in which teachers use interactions and conversations with children to support learning.[7]

Connecting Theories to Environments

Environments should be planned with developmental theories in mind:

- **Jean Piaget and the Cognitive Theory:** Environments should encourage active learning, stimulate skills of inquiry and promote problem-solving/risk-taking. Examples: Materials are placed low on shelves that make easy access for children. The shelves should be labeled with pictures of the materials so that children are encouraged to place these materials where they belong by matching the material to the photo when they finish playing with them. The environment must be stimulating for children to encourage knowledge seeking.
- **Vygotsky and the Sociocultural Theory:** Environments should provide opportunities for meaningful interactions that challenge children (Zone of Proximal development--ZPD) and in which scaffolding exists through child-child and child-adult interactions.
- **Behavioral Theory:** Daily routines must be consistent and expectations of behavior should be clearly defined.
- **Erikson:** Environments provide opportunities for children to develop feelings of trustworthiness, autonomy, and initiative in the early years. The environment provides areas for children to feel safe, play independently, and make choices throughout the day.

[8]

Curriculum Occurs Throughout the Day

As previously stated, young children learn in everyday moments of play and interaction. A child who arrives in the classroom and sees his name written on a cubby where he deposits what he brought from home is learning. That learning is amplified when he walks to a nearby metal tray (labeled with the words “Home” and “School”) and moves the magnet attached to his photo from the “Home” side of the frame to the “School” side. The learning continues when he stops to write his version of his name in the sign-in binder, located near a ring of cards with a child’s name and photo printed on each. In this area, he can observe the accompanying family member sign him in as well. Remember, you can incorporate STEM learning into routines such as these by asking a “Question of the Day” related to STEM experiences to occur later in the day. One example would be to ask, “How much rain do you think we will get today?” The children could indicate the number of inches they think will fall during the day. The teacher and the students could put out a rain gauge and check it the next day. The class could then analyze their guesses and compare it to the amount of rain that fell. Then the class could discuss if their predictions were too high or too low, etc..

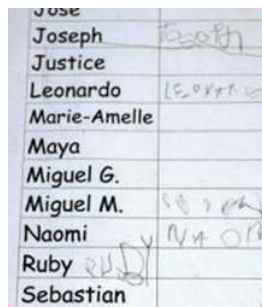


Figure 5.3: An example page from a sign-in binder.[9]

A bit later, that same child is learning when he describes to the teacher his frustration that his “favorite tricycle is still being used by another child.” The teacher suggests what he might say to encourage the other child to explore how the two of them might cooperate. After that conversation, his learning continues as he ventures into the block area and takes on the challenge of turning a container of blocks and boxes into a gas station, negotiating varying roles in the pretend play with his friends. At lunch, when he pours milk into his glass using a small measuring cup, he is learning. Each moment of learning, in this example, emerged from thoughtful, intentional curriculum planning. Early childhood teachers plan such opportunities for young children to learn throughout the day.

Teachers’ early childhood curriculum plans include the physical space as a context for learning. This means that teachers plan what, when, and how materials and furnishings are made available to the children for use. Teachers also plan the social environment—the roles, responsibilities, and guidance offered to children—during the daily routines and during moments of spontaneous interactions. A broad definition of curriculum includes the following components:

- Play spaces designed as environments for learning

- Care routines designed to invite children's active participation
- Interactions and conversations with children that support their understanding of themselves and others

Play Spaces as Curriculum

With play being central to the way in which children construct knowledge about the world around them, an important task for teachers is to develop play spaces thoughtfully and purposefully. Play spaces are children's environments for learning. Seeing children as young scientists leads to the creation of play spaces that become the children's laboratories for learning. Whether inside or outside, their play spaces are where they explore, experiment, and solve problems. Play spaces include materials and furnishings that invite children to figure out what the world is like and how it works. When early childhood teachers thoughtfully select and organize materials for play, they support an essential aspect of curriculum—self-initiated exploration, investigation, and invention of ideas. Jones and Reynolds (2011) list the varied roles assumed by early childhood teachers, one of which they call “stage manager.” This role means that the early childhood teacher purposely sets the stage for learning by selecting toys, furnishings, and materials that invite children to explore, experiment, and solve problems. In a well-designed early childhood program, the play environment holds immense possibilities for learning and creativity.

Consider how the play environment provides a context for learning in the following vignette:

Vignette

Art Area Example:

During a moment of play in the art area, infant teacher Joette watches as two-year-old Lucila picks up a wooden frame that encloses two sheets of blue plexi-glass. Lucila puts her eyes up close to the plexi-glass and peers through. She holds the frame out to Joette, gesturing for her to take it. Joette responds, “You want me to see what you saw, don’t you? I’d love to!” Joette looks through and exclaims, “I see everything blue! Here, your turn, Lucila.” Lucila looks through the block again. Another child walks up and reaches for a different frame, this one with yellow plexi-glass inside. The two children laugh together as they move the frames back and forth in front of their eyes. Teacher Joette watches and then picks up a third frame, which has red plastic sheets. She holds it near the window, and a red patch appears on the floor. She gestures to the two toddlers and says, “Oh, look what’s over here!” They rush to the red patch. Lucila steps onto the red and laughs with excitement. “It made red!” she says. “Yes!” says teacher Joette, “Will yours make a color on the floor, too? You want to try?” Lucila holds her frame to the sun, sees a blue spot, and says, “Yes, I made blue!”^[10]

Infant and Toddler Play Example:

Here's a vignette illustrating how the play environment provides a context for STEM learning in a preschool setting for infants and toddlers:

As the morning sun filters through the windows of the infant and toddler classroom, the play environment comes alive with the sounds of giggles, babbling, and the gentle hum of exploration. In one corner, a group of infants gathers around a sensory table filled with colorful balls of various sizes and textures. Their tiny hands reach out, grasping and squeezing the soft and bumpy balls, exploring the concepts of shape, texture, and cause-and-effect as they roll the balls back and forth.

Nearby, a pair of toddlers engages in a collaborative building project, stacking oversized foam blocks to create a towering structure. They experiment with balance and stability, problem-solving as they adjust the blocks to prevent the structure from toppling over. Their laughter and animated conversations reveal their excitement and engagement in the process of building and creating.

In another area, a caregiver sits with a small group of infants, introducing them to a set of brightly colored nesting cups. The infants watch intently as the caregiver demonstrates how to stack the cups from largest to smallest, exploring concepts of size, order, and spatial relationships. With gentle encouragement, the infants eagerly mimic the stacking action, delighting in the discovery of new patterns and sequences.

As the morning progresses, the play environment continues to evolve, offering a myriad of opportunities for STEM learning. Infants and toddlers explore water play at the sensory table, investigating concepts of volume and buoyancy. They experiment

with simple musical instruments, exploring sound and rhythm. They engage in outdoor exploration, observing nature and discovering the wonders of the natural world.

Through play, the infants and toddlers in this classroom are immersed in a rich STEM learning environment. The play materials, activities, and interactions are carefully designed to stimulate curiosity, promote hands-on exploration, and foster the development of foundational STEM skills. In this nurturing and stimulating environment, every moment of play becomes a valuable opportunity for learning and discovery.

How to incorporate the interests and skills of the children into the STEM environment was generated using OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. <https://chat.openai.com>

The above example illustrates how the environment provides a context for STEM learning for infants and toddlers. Think about how the environment can provide a context for STEM learning for preschool age children.

It is easy to see evidence of the children's thinking in this moment of play. They take full advantage of the materials available in this well-stocked play space designed to prompt play with colors and textures of materials. They notice the distinct features of the panes of translucent plastic. They compare them as they play. They use one item in relation to the other. They experience how they can use the different-colored panes to transform the shadows on the floor. They explore how the shapes change in space and how their actions cause different reactions. The inventions of one child are exchanged with those of the other. In this play space, children can be seen constructing concepts of shape, orientation, light, and transformation.

Joette and her co-teachers supplied this art area with the same care that scientists might stock their laboratories. In the art interest area for toddlers, they placed an array of toys and materials that invite exploration and comparison of color, line, shape, and texture. They made certain that there were objects with similar features as well as distinct features, in order to challenge the toddlers' emerging ability to sort one object from another. They gathered similar objects graduated in size, in order to challenge the toddlers to explore concepts of size and sequencing. In the collection were identical objects for creating pairs and for assembling many rather than few. The teachers made the materials easily available to the toddlers, on low shelves and in wide, shallow baskets and bins. A variety of containers were labeled, each holding a distinct type of object—objects made from paper in one; a collection of orange and red fabric pieces in another; a collection of blue fabric, feathers, and ribbons in another; and a collection of translucent colored frames in another.

In the natural course of spontaneous play, toddlers encounter such materials and build relationships of identity, order, size, shape, number, and space. Many of the materials, like the collection of fabric pieces, are familiar to the toddlers, already available in the bins of the play space for many days. Other materials, like the long pieces of translucent cellophane paper in a variety of colors, have been recently added by teachers, with the hope of extending and adding complexity to the toddlers' play with color.

The new materials added to the play space are part of the teachers' curriculum plan. During their weekly planning, Joette and her co-teachers discuss the observations they made of Lucila and her friends as the children explored the colored panes of plexi-glass. As the teachers interpreted the play, they wondered how to add some challenge and surprise to the toddlers' enjoyment of making colored shadows on the floor with the sunlight and the translucent plastic. The subsequent curriculum plan held a question: "In what ways will the children explore the long lengths of colored cellophane that they discover in the art area?" The teachers wondered whether these new materials might provoke toddlers' deeper exploration of relationships of size, space, and similarity and difference. The teachers explored possible questions to prompt toddlers' experiments in transforming the primary colors in the yellow and the blue cellophane into the secondary color of green.

Once the stage is set for play, teachers observe to discover what will ensue. At times, teachers might narrate what goes on as the children play, offering language related to the play. The teachers might also prompt new ways of looking at the materials, as Joette did when she held the colored pane near the window to catch the sunlight and cast a colored shadow. In this moment, she artfully *scaffolded* the toddlers' learning by suggesting a new way of playing with the plexi-glass. A scaffold is a structure that allows someone to go higher in order to accomplish a task that the person could not have done alone. Teachers scaffold children's play when they connect in shared knowing with children and support them in going further to figure something out.

Environmental Factors in Supporting Math

Here are some things to consider and remember when setting up your environment to support mathematical learning.

Young children actively construct mathematical knowledge through everyday interactions with their environment. Setting up a high-quality physical environment is essential for children’s mathematical development. The preschool environment sets the stage for children’s physical and social exploration and construction of mathematical concepts. It should provide access to objects and materials that encourage children to experiment and learn about key mathematical concepts through everyday play.

- Enrich the environment with developmentally appropriate, challenging, and engaging materials that promote mathematical growth
- Integrate math-related materials into all interest areas in the classroom
- Use materials, books, and real-life settings that reflect the culture, ways of life, and languages of the children in the group
- Use children’s books to explore mathematics with children
- Be intentional and mindful in setting up and using the physical environment (children do not effectively use materials and engage in experiences just because you provide them)[1]

Environmental Design

Rich learning environments with a variety of activities enhance young children’s learning and development. In an environment in which children have the opportunity to make observations, ask questions, plan investigations, gather and interpret information, and communicate findings and ideas (CDE 2012b, 53), they explore concepts in domains such as science, math, and history–social science. Dance, music, and drama not only introduce children to the arts and allow them to explore creative processes, they also provide opportunities for children to learn to regulate their behavior and take the perspective of another person.[11]

Creating Environments for Infants and Toddlers

The infant/ toddler framework proposes the following play spaces to consider for an infant/toddler program:

- A cozy area for books and stories
- A small-muscle area
- A sensory perception area
- An active movement area
- A creative expression area

While you consider these areas in your classroom, think about how you will integrate STEM into these areas.

Here is a sample infant/toddler classroom. See Appendix B for an older toddler classroom and for the corresponding blueprints.



Figure 5.4: An infant/toddler classroom.[12]

Creating Environments for Preschoolers

The preschool framework offers the following list of suggested play spaces when creating a learning environment for children three to five years of age:

- Dramatic play area
- Block area
- Art area

- Book area
- Writing area
- Math area
- Science/Sensory area
- Family display area
- Music/movement
- Meeting area (for conferencing)

Once again, as you think about the areas you will have in your classroom, reflect on how you will integrate STEM learning into the areas.

Here is a sample preschool classroom. Additional sample classrooms for preschoolers and corresponding blueprints can be found in Appendix B.



Figure 5.5: A preschool classroom.[13]

In both cases, it is helpful to think of ways that the spaces can be used by two or three children together, one child alone, or an adult and one or two children, as well as larger areas for more exuberant group play. Providing opportunities for small configurations enables the play space to support growing social relationships and meet needs of children who prefer more defined space or space away from others. [14]

Licensing Requirements for Indoor Preschool Classrooms

All states have childcare and K-12 requirements. You may view licensing requirements specific to [Wisconsin group childcare centers](#) or specifically the Wisconsin requirements regarding [plant and furnishings](#) and the Wisconsin Department of Instruction (DPI) [Facility Regulations](#).

Here are a few of the licensing requirements to keep in mind when planning **indoor environments** for young children in California:

- The program provides for quiet and active play, rest and relaxation, eating, and toileting. (101230)
- 35 square feet of indoor activity space per child (not including bathrooms, halls, offices, food preparation areas, or storage. (101238)
- That each child has individual storage space for clothing, personal belongings, and bedding. (101238).
- Storage must be provided for play materials, equipment, and napping equipment. (101238)
- Combustibles, cleaning equipment and cleaning agents shall be stored in an area separate from food supplies in a locked cabinet or in a location inaccessible to children. (101238)
- Tables and chairs scaled to the size of children must be provided. (101239)
- All play equipment and materials used by children must be age-appropriate. (101239)
- Drinking water must be available freely to children. (101239)[15]

Ensuring Quality in the Indoor Environment

Tools, such as Environment Rating Scales, can be used to help ensure the environment is high quality. Here are some items that describe high-quality indoor environments for preschool-aged children according to the Early Childhood Environment Rating Scale (ECERS). A full checklist can be found in Appendix C.

- Space is accessible to children and adults, including those with disabilities
- There is ample space for the people and furnishings
- Adequate storage and seating
- Storage for play materials and personal belongings are accessible to children
- Cozy spaces and other soft furnishings and materials are provided
- At least five of the following centers are provided and accessible to children:
 - Art
 - Blocks
 - Dramatic Play
 - Reading
 - Nature/Science
 - Manipulatives/Fine Motor
- Spaces for active and quiet activities are separated
- There is more than one space for a child to have privacy
- Children's work makes up a majority of the classroom display
- Diversity is featured throughout the space (people of different races, cultures, ages, abilities, and gender in non-stereotyping roles)
- New materials are provided/rotated at least monthly
- The following materials are provided to children
 - Books feature many topics/genres
 - Fine motor toys (such as building materials, puzzles, art materials, and manipulatives)
 - Art materials (such as drawing materials, paints, play dough, clay, collage materials, and tools)
 - Musical instruments and different types of music
 - Blocks (such as unit blocks, large hollow blocks, and homemade blocks) and accessories
 - Dramatic play equipment and props
 - Sand and water play equipment and materials (such as containers, funnels, scoops, and accessories)
 - Natural materials (such as collections, living things, books, games, toys, and tools)
 - Materials featuring numbers and shapes
- All materials are organized and in good condition
- Materials of differing levels of difficulty are provided[16]

Outdoor Spaces

The areas highlighted in the frameworks should be represented in outdoor play spaces as well. Materials may vary but all areas should be reflected in both the indoor and outdoor environments.

Many outdoor spaces feature play equipment, such as what is shown in the following image, which is a great way to provide for children's large motor play and exploration.



Figure 5.6: An outdoor play area.[17]

But materials and experiences that would typically be indoors can easily be taken outside as well.



Figure 5.7: Caption: musical instruments can be explored indoors or outdoors[18]

A variety of additional equipment can be purchased to expand children's experiences outside, although a large budget is not required to create high quality outdoor spaces for young children.



Figure 5.8: Sensory play is one of the most popular activities for young children. While this setup allows for many children to play, less elaborate spaces would still create quality experiences for children.[19]



Figure 5.9: These children are busy building. Similar activities could be done with non-commercial materials.[20]

Programs may choose to provide a playground made of natural materials to immerse children in nature as well.



Figure 5.10: This preschool features nature heavily. Children can engage in many of the same experiences outdoors with these natural materials and "equipment." [21]

Licensing Requirements for Outdoor Preschool Classrooms

All states have some type of licensing requirements for preschool environments. **Outdoor Requirements for Wisconsin can be viewed here** [DCF 251.06 Physical plant and equipment. \(11\) OUTDOOR PLAY SPACE.](#)

The following are some licensing requirements that programs in California should incorporate in the design and planning for their outdoor space:

- There shall be at least 75 square feet per child of outdoor activity space. (101238)
- The outdoor space shall permit children to reach the space safely. (101238)
- A shaded rest area should be provided. (101238)
- The surface of the activity space shall be in a safe condition and free of hazards. (101238)
- The areas around and under climbing equipment, swings slides and similar equipment shall be cushioned with material that absorbs falls. (101238)
- Equipment and activity areas shall be arranged so that there is no hazard from conflicting activities. (101238)
- Sandboxes shall be inspected daily and kept free of foreign materials. (101238)
- The playground shall be enclosed by a fence at least four feet high. (101238)
- Hazardous equipment such as a fuse box shall be inaccessible. (101238)[\[22\]](#)

Ensuring the Quality of the Outdoor Environment

According to the ECERS, here are some items that describe high quality outdoor spaces for children. See Appendix C for the full checklist:

- There is adequate space for gross motor play
- The space is easily accessible to children
- The space is organized so activities do not interfere with one another
- The following materials are included
 - Stationary equipment (such as, swings, slides, climbing equipment)
 - Portable equipment (such as, wheeled toys, mats, jump ropes, bean bags, balls)
 - Equipment that stimulates
 - § Balancing
 - § Climbing
 - § Ball play
 - § Steering
 - § Tumbling
 - § Jumping
 - § Throwing
 - § Pedaling
- Equipment provides skill development at multiple levels
- Enough equipment that children do not have to wait long to play
- Equipment is in good repair
- Equipment is appropriate for the age and ability of the children
- Adaptations are made for children with disabilities[\[23\]](#)

The environment and how it is set up is as important as the activities and interactions the teachers plan in supporting the development of learning in all domains.

Pause to Reflect

How Does the Outdoor Environment Foster Development?

Taking children on nature walks keeps them grounded and allows us an opportunity to nurture their connection to the natural world. Expressing positive emotions promotes a natural curiosity and appreciation of our cosmological (relating to the origin

and development of the universe.) family. Ask questions, encourage their inquisitive nature, and foster their imagination to build a life-long relationship with the outdoors.

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CHAPTER OVERVIEW

4: Early Science Experiences

- 4.1: Introduce Children to Science Through Observation
- 4.2: Using Tools to Support Science Learning
- 4.3: Scientific Inquiry
- 4.4: Helping Children Form Explanations
- 4.5: Science Methods

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4.1: Introduce Children to Science Through Observation

Course Competency 4. Examine strategies that teach early science skills.

Criteria 4.1 identify observation skills used to gather information.



Preschool teachers help children explore science concepts in hands-on ways. By observing, using tools, forming explanations, and incorporating the scientific method, children can learn and engage with science in a fun and interactive way. It's important to start early in developing an interest in science, and preschool is the perfect time to do so. As you read the introduction to this chapter you will discover the integrated nature of science learning. The steps of the scientific process are interdependent. It is difficult to isolate the steps of the process because each of the steps builds upon the previous one and influences the next. We will explore how children are naturally inquisitive and what teachers can do to support their growing scientific understanding. **As you read the information below, think about how children are using observation skills and how teachers are helping to develop observation skills in children.**

Children are Natural Scientists

Children have a sense of wonder and natural curiosity about objects and events in their environment. Just like scientists, they seek information and actively explore and investigate the world around them, try things out to see what happens, and confirm or adjust their expectations.

Science is a natural and developmentally appropriate focus for young children. Preschool science is about active learning, not memorizing scientific facts or watching the teacher perform science demonstrations. The purpose of preschool science is to nurture children's habits of inquiry, critical thinking, creativity, innovative problem solving, open mindedness, and the motivation to learn. Preschool science guides children's natural curiosity into opportunities to observe, explore, and inquire about basic phenomena and materials in their world. **Preschool teachers can help children learn to observe by modeling how to observe.**

From infancy, children gain knowledge and develop concepts about living things and physical objects. Preschool science provides children with focused experiences that allow them to learn ways to explore and extend their knowledge. Children begin to adopt scientific ideas and to acquire the basic skills and language of scientific inquiry (ways to explore and develop knowledge and understanding of scientific ideas). Making observations, posing questions, planning investigations, using tools to gather information, making predictions, recording information, and communicating findings and explanations all combine in an evolving process of developing science understanding and creating a disposition to choose to learn science in the future.

Science can be conducted in any preschool setting. All preschools, regardless of the level of resources and access to nature, can use their existing resources to create a program with meaningful science learning experiences. Pushing cars down an incline, building with blocks, manipulating tubes at the water table, or mixing clay with water are everyday play activities that engage children in experimenting with objects and materials. Collecting leaves, searching for insects in the yard, sorting and classifying fruits and vegetables, and sprouting seeds in pots engage children with living things. Experiences of child-initiated play are important as they provide children with opportunities to construct understanding and integrate knowledge. With teachers' intentional planning, guidance, and support, children's play and interactions with objects can become rich experiences of scientific inquiry and facilitate children's knowledge and understanding of objects and events in the world.

Preschool teachers play a pivotal role in expanding children's understanding of science concepts and developing children's attitudes, skills, and the language of scientific inquiry. The teachers can focus children's attention on particular science concepts, those that are developmentally appropriate, interesting, and engaging for both children and teachers. They can create engaging inquiry experiences, encouraging close observations of objects and events.

Children may draw the connection to their own growth and the growth of other animals and begin to develop a broader understanding of living things. Such experiences of scientific inquiry not only support children's development of scientific knowledge, but provide a natural vehicle for developing children's social skills, and their development in mathematics, language, literacy, and other domains.



Figure 4.1: A teacher used background knowledge to help the children create this bilingual butterfly life cycle documentation.[1]

Preschool teachers do not need to have extensive knowledge about science in order to teach it well, but they should be willing to research and gain general knowledge of the concepts and principles they explore with children. The kind and amount of information or knowledge they need to know is readily available through basic research. Acquiring some background knowledge about the topic helps teachers in planning inquiry experiences and challenging and supporting children through their explorations.

Teachers do not need to have answers to all the questions children will raise. Rather than providing children with answers, teachers can use children's questions as a springboard for further investigations. They may say, "I don't know. Let's find out together." It is essential that teachers become "scientists" together with children, model a questioning mind for children and think out loud, expressing interest and enthusiasm. Teachers' thoughtful guidance and support through inquiry experiences builds a foundation for children's understanding of basic science concepts, fosters a positive approach to learning, and develops learning skills and attitudes necessary for later success in science and in other subjects.[2]

The following principles guide teachers in establishing a preschool science program that fosters children's curiosity and develops their skills and habits to explore and learn about their world. These principles are consistent with a constructivist approach to learning, where children actively construct knowledge through physical and mental interactions with objects and people in their environment. The principles are drawn from current research-based models and approaches to early childhood science and are consistent with the National Association for the Education of Young Children (NAEYC) guidelines on developmentally appropriate practice.

- The preschool environment supports children's curiosity and encourages inquiry and experimentation
- The teacher
 - acts as a researcher, joining children in exploring their world
 - asks open-ended questions to encourage children to think and talk
 - introduces children to new vocabulary, including scientific terms such as observe, explore, predict, and measure
 - demonstrates appropriate use of scientific tools
 - invites children to reason and draw conclusions
 - encourages children to share their observations and communicate their thoughts
 - models respect for nature
- Content of inquiry is developmentally appropriate and builds on children's prior experiences
- Scientific inquiry experiences are interesting and engaging for children and teachers
- Children explore scientific concepts directly through active, hands-on, minds-on playful experiences
- Children explore scientific concepts in depth through multiple, related learning experiences over time
- Children construct knowledge through social interactions with peers and adults
- Children use language and other forms of communication to express their thoughts, **describe observations**, and document their work

- Teachers support children who are English learners in understanding and communicating scientific knowledge and skill
- Science is embedded in children's daily activities and play and provides a natural vehicle for integrating mathematics, literacy, and other content areas
- Individual differences are recognized, and all children are included and supported
- The preschool environment, home, and community are connected through science.

Early childhood science education relies heavily on the observations of the children. The children need teachers who can wonder along with them and guide their observations by helping them describe and communicate their observations to others.

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4.2: Using Tools to Support Science Learning

Course Competency 4. Examine strategies that teach early science skills.

Criteria 4.2 identify tools to gather information and compare observed objects.

What are Tools?



As you learned in the previous section, children learn about science through their observations. Teachers can guide children's observations through the use of tools. Tools can be anything that teachers use to help children learn through observation, documenting their observations and discussing them. The environment and the materials in it as well as the language teachers use can be tools in preschool science.

Tools in the Environment

Preschool teachers can support and enhance that learning by how they set up the learning environment. Indoor and outdoor environments provide the context for children's physical and social explorations and construction of scientific concepts. The following are strategies for helping teachers set up a physical environment that is rich, stimulating, and conducive to

children's construction of knowledge. All of the strategies are things preschool teachers must keep in mind however, the bolded strategies apply specifically to the use of tools in early childhood science.

- Be thoughtful about what objects and materials to include in the environment
- Provide a variety of natural materials to observe and investigate
- Include objects and materials that allow for creativity and open-ended investigation
- Include living things in the preschool environment
- **Include scientific tools for observation, measurement, and documentation**
- **Make scientific tools available throughout the preschool environment**
- **Consider adaptations in scientific tools and materials for children with special needs**
- **Use technology to support children's scientific experiences**
- Present documentation of science-related experiences in the preschool environment
- **Include children's books with science-related content**
- Use the outdoors for natural explorations and investigations
- Organize the space in ways that promote children's explorations
 - **Allow space for observations and for objects, materials, tools, and resources related to science**
 - Allow for flexibility in the use of physical space and furniture to accommodate the changing needs of each activity
 - **In order to promote self-direction and free explorations, tools and materials need to be accessible and consistently available to children**
 - Social interactions are necessary for conceptual growth and the development of communication skills
- Always be aware of children's safety
- Foster children's curiosity and questioning
- Guide children in exploring their questions
- Be an active observer
- Talk with children and engage them in conversations during their investigations
- Provide children with time.
- Know when to intervene and when to stand back
- Model the use of scientific vocabulary^[1]

Language and Vocabulary as a Tool in Preschool Science

Language is a powerful tool in preschool science education, serving several important purposes:

1. ****Communication:**** Language allows teachers and children to communicate about scientific concepts, observations, questions, and findings. It enables children to express their ideas, thoughts, and curiosity related to science.
2. ****Vocabulary Development:**** Science activities and discussions introduce new vocabulary related to scientific concepts, materials, processes, and phenomena. Through exposure to these words and terms, children expand their vocabulary and develop a deeper understanding of scientific language.
3. ****Conceptual Understanding:**** Language helps children develop a conceptual understanding of scientific concepts. Teachers use language to explain abstract ideas, make connections between concepts, and guide children in forming mental models of scientific phenomena.
4. ****Questioning and Inquiry:**** Language encourages questioning and inquiry-based learning in preschool science. Teachers use open-ended questions to prompt children's curiosity, critical thinking, and exploration of scientific topics. Children learn to ask questions, make predictions, and seek answers through observation and investigation.
5. ****Observation and Description:**** Language is used to describe observations, experiences, and findings during science activities. Children learn to use descriptive language to communicate what they see, hear, touch, smell, and taste, enhancing their observational skills and attention to detail.
6. ****Storytelling and Narratives:**** Storytelling and narratives are powerful tools for conveying scientific concepts in a relatable and engaging way. Teachers use storytelling to introduce scientific topics, explain processes, and connect scientific ideas to children's everyday experiences.
7. ****Collaboration and Discussion:**** Language facilitates collaboration and peer-to-peer discussion in preschool science. Children engage in conversations, share ideas, compare observations, and work together to solve problems and explore scientific concepts.
8. ****Documentation and Reflection:**** Language supports documentation and reflection on learning experiences in preschool science. Teachers help children document their observations, experiments, and discoveries using language through drawings, written notes, or verbal reflections. This process encourages children to think critically about their learning and communicate their understanding.

Overall, language plays a fundamental role in preschool science education by promoting communication, vocabulary development, conceptual understanding, inquiry-based learning, observation and description, collaboration, storytelling, documentation, and reflection. It serves as a bridge between children's experiences, thoughts, and discoveries in the world of science. OpenAI. (2024, May 5). The role of language in preschool science education. [Chat with ChatGPT]. Retrieved from conversation with ChatGPT.

Using Scientific Vocabulary

Teachers can help children learn new vocabulary and think like scientists by using scientific vocabulary and explaining what they mean. See the table below for examples of some of the scientific vocabulary you use with children.

Table 4.1: Scientific Vocabulary[2]

Words that can be used to describe scientific activities:

Observe, observation

Predict, prediction

Test

Similar, different

Compare, contrast

Count

Measure

Investigate

Explore

Experiment

Discover

Record

Explain

Hypothesis

Scientific Tools for Preschoolers

There are many types of tools young children can use to guide and enhance their scientific understanding. Preschool teachers can model how to use them and provide opportunities for children to practice using the tools so the children know how to use them during their scientific observations and investigations. See the table below for some of the types of tools children may use.

Table 4.2: Suggested Scientific Tools^[3]

Types of Tools	Names of Tools
Observation Tools Tools to extend close observations	• Magnifying glasses, hand lenses • Binoculars • Tweezers • Microscope Trays (Collectors' trays)
Measurement Tools Tools for measuring length, height, weight, volume, and temperature	• Tape measures, strings, unit blocks • Rulers Scales (e.g., balance scale, bathroom scale) • Measuring cups • Measuring spoons • Thermometer
Recording Tools Tools for recording and documenting information	• Pencils, markers, crayons • Science notebooks/journals, charts • Papers, posters • Camera, computer • Felt board, magnet board • Materials to create 3-D models

Using Materials as Tools

Teachers can use a variety of different materials in scientific experiences. Teachers may have the children observe or analyze the materials or children may use the materials as tools to help them do something or complete a task.

Table 4.3: Suggested Open-Ended Materials^[4]

Types of Materials	Names of Materials
Materials for Building and Construction Open-ended materials can be used in multiple ways and therefore allow for investigation, creativity, and problem-solving	Sample Materials: • Blocks of various shapes, sizes, and materials (e.g., wood, foam, cardboard) • Boxes • Cardboard, planks, ramps • Carpentry tools • Gutters, hollow tubes • Logs • Nuts and bolts • Screws • Sticks • Straws • Wheels, wheeled objects • Other construction materials
Collections of Objects and Reclaimed Materials For exploration of diverse materials and use in sorting, classifying, and ordering activities	Sample Materials: • Bottles • Boxes of various sizes • Buttons • Collection of balls of different sizes • Collection of different types of animals (for sorting and pretend play) • Collection of household tools made from metal, wood, plastic • Collection of musical instruments • Corks • Fabrics (e.g., a collection of gloves made of wool, rubber, leather) • Glass nuggets • Metal lids • Plastic lids • Screws • Shakers, maracas, castanets • Styrofoam pieces • Wind chimes • Woodchips
A Variety of Substances/ Materials	• Cooking utensils • Corn starch • Dough • Eggshells • Flour • Liquids • Salt • Sugar
Natural Materials: Earth Materials Natural materials found on earth	• Clay • Crystals • Minerals • Rocks • Sand • Seashells

Types of Materials	Names of Materials
	• Soil • Tools to dig and explore soil (e.g., trowels, containers, magnifiers, trays) • Tools to explore water (e.g., water table, clear plastic tubes, connectors, funnels, containers) • Water
Natural Materials: Plant Materials Materials derived from plants and animals	• Bark • Cotton • Feather • Fruits • Fur • Leaves • Seeds, seed pods (e.g., pinecones) • Tree logs • Twigs • Vegetables

Research Highlight

Children bring to science many ideas about how things work. These intuitive understandings or naïve theories that children have constructed often conflict with what is known to be scientifically correct. Children hold preconceptions and misconceptions about different topics of science including forces, changes of matter, light, sound, and earth phenomena. For example, children believe that water disappears when it evaporates or that rain occurs when clouds are shaken. It is important to know how these conceptions differ from the scientific explanation and why children construct these ideas. Children's misconceptions are intuitively reasonable, from the child's perspective, and are used by children to explain the "why" behind physical events. Some of children's ideas may be cultural beliefs that have been introduced at home. The teacher's role is to guide children through numerous opportunities to discover and re-create concepts, without overtly correcting their misconceptions. Remember, science is about experimentation, and the goal is to support children's scientific thinking, not to merely provide the correct answer.[5]

Sources:

C. E. Landry and G. E. Forman, "Research on Early Science Education, in *The Early Childhood Curriculum: Current Findings in Theory and Practice*, 3rd ed., ed. C. Seefeldt (New York: Teachers College Press, 1999).

N. L. Gallenstein, *Creative Construction of Mathematics and Science Concepts in Early Childhood* (Olney, MD: Association for Childhood Education International, 2003)

References

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- [2] [The California Preschool Curriculum Framework, Volume 3](#) by the California Department of Education is used with permission
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4.3: Scientific Inquiry

Course Competency 4. Examine strategies that teach early science skills.

Criteria: 4.3. incorporate the scientific method into learning experiences.

Organization of Science Learning

Preschool learning foundations for science can be organized into four broad categories or strands.

- Scientific Inquiry (Process--How to "do" science)
- Physical Sciences (Content--What children learn)
- Life Sciences (Content--What children learn)
- Earth Sciences^[1](Content--What children learn)

The four categories above are divided into **process standards** and **content standards**. Process standards refer to how to think about science or "do" science while content standards refer to the science content or the things children will learn. Some states, such as Wisconsin, incorporate only process standards or scientific inquiry into their early learning standards and only focus on scientific inquiry. Other states, such as California organize their early learning standards into the 4 categories and incorporate both process and content standards. In Section 4.3 we will explore the process standard of scientific inquiry. You will learn more about the content standards in Section 4.5

Supporting Scientific Inquiry

Young children's experience of science is an interplay between content knowledge (what children learn about) and inquiry skills (the skills and processes they apply to explore and develop knowledge and understanding of scientific ideas). Children build knowledge and understanding of concepts through active participation in the process of scientific inquiry. Like scientists, children have a natural desire to inquire, but they need guidance in developing the skills of scientific inquiry.

- **Observation and investigation skills** involve ways to observe, compare, measure, classify, predict, and to check and investigate objects and events.
- **Documentation and communication skills** are employed to record information and to communicate findings and explanations with others.

Skills of scientific inquiry provide children with the tools for investigating and learning about science topics. Such experiences build habits of questioning, critical thinking, innovative problem solving, communication, collaboration, and decision making.

Scientific inquiry skills are integral to children's ongoing play and explorations and are not taught in isolation. Children develop their abilities to make observations, ask questions, and gather information, as part of meaningful exploration and investigation experiences. Teachers can establish an environment with a culture of inquiry and facilitate children's use of scientific skills and language through everyday explorations and planned experiences of scientific inquiry.

The table below shows the developmental progression of observation and investigation skills.

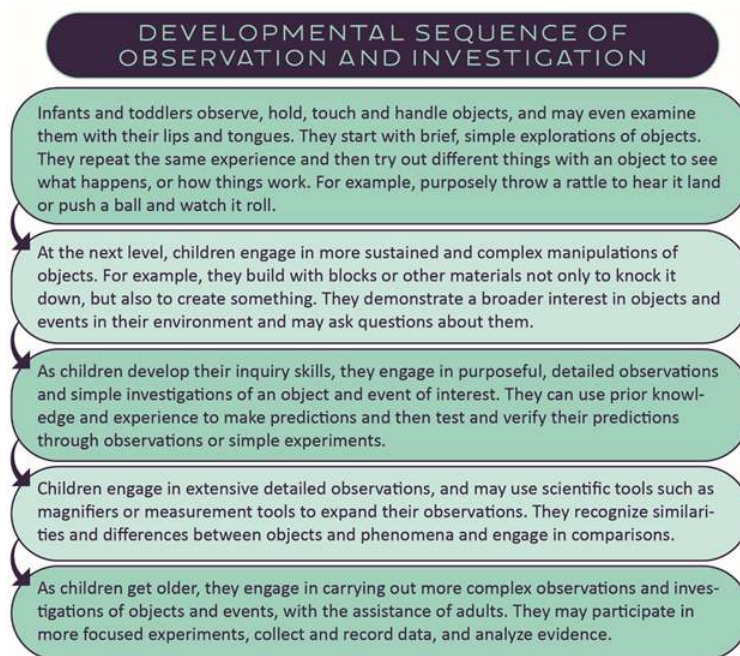


Figure 4.2: Image by Ian Joslin is licensed by [CC-BY-4.0](#)

Scientific Inquiry in WMELS

The Wisconsin Model Early Learning Standards have 4 standards for scientific inquiry.

C. EL.1 Uses observation to gather information.

C. EL. 2 Uses tools to gather information, compare observed objects, and seek answers to questions through active investigation.

C. EL. 3 Hypothesizes and makes predictions.

C. EL. 4 Forms explanations based on trial and error, observations, and explorations.

See the **Wisconsin Model Early Learning Standards** to view the progression of scientific inquiry skills from the earliest developing skills to later developing skills. WMELS doesn't assign an age range as all children develop at different times and rates. You may find the Wisconsin Model Early Learning Standards for Scientific Thinking on page 96 of the [WMELS](#) publication. There you will see the **Developmental Continuum** which is a sequence of accomplishments in the order in which they emerge. There will also be **Sample Behaviors** of children which will provide examples of what children might do if they are developing or learning the skill in the developmental continuum. The **Sample Strategies for Adults** will show examples of what adults might do to help children develop the skill in the developmental continuum.

Other states have chosen to connect age ranges to their standards. The examples below are taken from the California Preschool Curriculum Framework and show how scientific inquiry skills develop and change from 48 months to 60 months of age. The information from California is included as a reference to see when these skills might occur. Please keep in mind that all children develop at their own rate and time.

At around 48 months of age	At around 60 months of age
1.1 Demonstrate curiosity and raise simple questions about objects and events in their environment.	1.1 Demonstrate curiosity and an increased ability to raise questions about objects and events in their environment.
1.2 Observe ¹ objects and events in the environment and describe them.	1.2 Observe objects and events in the environment and describe them in greater detail.
1.3 Begin to identify and use, with adult support, some observation and measurement tools.	1.3 Identify and use a greater variety of observation and measurement tools. May spontaneously use an appropriate tool, though may still need adult support.
1.4 Compare and contrast objects and events and begin to describe similarities and differences.	1.4 Compare and contrast objects and events and describe similarities and differences in greater detail.
1.5 Make predictions and check them, with adult support, through concrete experiences.	1.5 Demonstrate an increased ability to make predictions and check them (e.g., may make more complex predictions, offer ways to test predictions, and discuss why predictions were correct or incorrect.
1.6 Make inferences and form generalizations based on evidence.	1.6 Demonstrate an increased ability to make inferences and form generalizations based on evidence.

References

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4.4: Helping Children Form Explanations

Course Competency 4. Examine strategies that teach early science skills.

Criteria: 4.4. form explanations based on trial and error, observations, and explorations.

How Teachers Help Children Form Explanations

Helping children learn how to observe and to use tools to aid in their observations is very important to science learning. It is also important for teachers to help children think about and discuss what they have observed. When teachers help children communicate about their observations and experiences they are helping children to form explanations by discussing and recording things they have seen, tried, or experienced.

Teachers can support children's development of the scientific inquiry foundations and help them form explanations with the following:

- Facilitate children's observation skills by using the term "observe" and introduce the process with a familiar item
- Talk with children and ask questions to guide their observations
- Invite children to observe objects and phenomena related to the current focus of inquiry
- Promote the use of scientific tools to extend children's observations and investigations of objects
- Introduce children to scientific tools and their function and support their appropriate use
- Encourage children to make predictions first and then check their predictions
- Remind children that predictions do not have to be right
- Record children's predictions
- Facilitate children's ability to make inferences and draw conclusions (when inferring and drawing conclusions, children observe what happened and make an assumption about the cause)
- Use everyday observations to model inferring
- Encourage children to explain the reasoning behind their inferences
- Encourage children to record observations and document investigations and findings
- Promote the use of different forms to record and document information
- Consider adaptations for children with special needs
- Encourage children to describe their representations while you write their words
- Encourage different means of communication including home language, sign language, and communication devices
- Invite children to record collaboratively, using charts, graphs, or models
- Ask open-ended questions to
 - Encourage children to share their observations
 - Facilitate problem-solving and investigations
 - Elicit predictions and explanations
- Engage children in collaborative discussions^[2]

The chart below shows the progression of children's ability to form explanations.

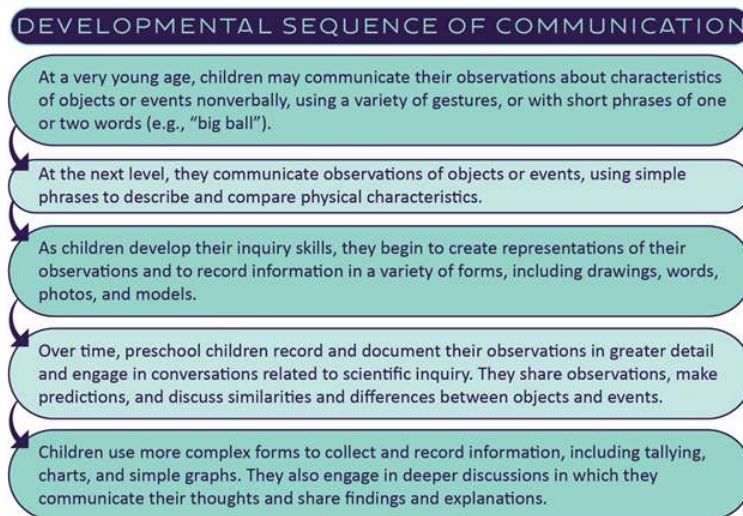


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WMELS: Scientific Thinking

Please see **Performance Standard: C.EL. 4** Forms explanations based on trial and error, observations, and explorations, in the [Wisconsin Model Early Learning Standards](#) for sample behaviors of the children and strategies of adults. Remember that the skills are listed in order of development, but no ages have been assigned as children develop at different rates and times.

The examples below are taken from the California Preschool Curriculum Framework and show how children, with adult assistance, can record observations and findings to form explanations and are provided once again as a reference. The chart below shows the progression of skills children's ability to form explanations from 48 months to 60 months of age.

2.0 Documentation and Communication

At around 48 months of age	At around 60 months of age
2.1 Record observations or findings in various ways, with adult assistance, including pictures, words, (dictated to adults), charts, journals, models, and photos.	2.1 Record information more regularly and in greater detail in various ways, with adult assistance, including pictures, words (dictated to adults), charts, journals, models, photos, or by tallying and graphing information.
2.2 Share findings and explanations which may be correct or incorrect, with or without adult prompting.	2.2 Share findings and explanations, which may be correct or incorrect, more spontaneously and with greater detail.

Engaging Families

Teachers can make the following suggestions to families to facilitate their support science learning. When preschoolers talk to their families about their science experiences children share their observations and any explanations they may have come up with about what they observed and what happened.

- Use science learning as an opportunity to involve families by inviting them to the program and by sending home suggestions for activities that they can do with their children.
- Communicate to families their important role in supporting children's curiosity and the development of scientific knowledge.
- Share with family members your approach to science and how you support children's development of inquiry skills.
- Invite family members to come and talk with the teacher and children about their beliefs and connections to nature
- Share the importance of active hands-on explorations of objects and materials
- Inform families about children's explorations and experimentations with objects and materials.
- Involve family members as volunteers and rich resources in the preschool environment.
- Provide families with enrichment and follow-up activities they can do with children at home.

- Ask families about children's previous experiences, cultural beliefs, and theories about living things.
- Share with families children's experiences with science in the classroom.
- Remind family members of the many opportunities to engage children in life science explorations outside the preschool environment.
- Provide family members with tips to support children's awareness and understanding of their natural environment.^[1]

References

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4.5: Science Methods

Course Competency 4. Examine strategies that teach early science skills.

Criteria: 4.5. develop methods to teach environmental science.

Science Content Standards

In Section 4.3 we learned there are 2 ways of organizing science learning. It can be organized into process and content standards. Scientific inquiry, or how to think about and "do" science is a process standard. The topics or knowledge about science are called content standards. In this section, we will look at 3 types of content areas or knowledge for science: physical, life, and earth.

As we look at the content for science below, remember the **Wisconsin Model Early Learning Standards** only has standards for **process standards** and **not for content standards** so you will not see references to WMELS for physical, life or Earth sciences. You will only see references to the California standards as they incorporate process and content standards.

Supporting Physical Sciences

Young children's inquiry in physical science involves the active exploration of nonliving objects and materials and of physical events in their everyday environment. When children build with blocks; play with different balls; push or slide objects of different kinds; play with water, sand, clay, and other objects in the preschool environment; they explore materials in different ways and begin to form ideas about the physical properties. They manipulate objects, act on them, and observe what happens. They may try a certain strategy over and over to see if the same result happens again. Through such exploratory interactions with objects and solid and nonsolid materials, children can learn about cause-and-effect relationships, the physical properties of objects and materials (e.g., size, shape, rigidity, texture), and about changes and transformations of objects and materials. For example, when building with various kinds of blocks, children may learn about the size and shape of the blocks and about the characteristics of the materials used to make the blocks (e.g., wood, foam, plastic). They may discover that the big cardboard blocks should be used at the bottom of a tower and the small unit blocks on top in order to create a strong and stable tower. When playing at the water table, they experience how water flows down and takes the shape of the container.



Figure 4.4: What containers could be added to this water table to expand the children's exploration?[4]

With teachers' guidance, children's everyday play can become rich, hands-on inquiry experiences of the key concepts in physical sciences. Teachers can provide children with materials to broaden their investigation. They encourage children to try out their ideas, even if the teacher knows the child's strategy will not create the desired result. Teachers challenge children's thinking by asking questions that focus attention on key science concepts being investigated: "What can you do to make the bridge higher?" "How can we make mud?" "Why did the ball roll down in this direction?" Interactions of this kind provide children with opportunities to extend their experimentations with objects, to notice patterns of cause-and-effect, to reason and think more deeply about the phenomena they observe, and to use language to describe, explain, and reflect on their work.

Key Concepts in Physical Sciences

In exploring objects and materials, children develop understanding of key concepts about the physical world.

- They learn about the size, shape, weight, texture and other properties of objects and materials.
- They learn about the form and function of objects and that the form of an object supports its function.
- They continue to learn about cause and effect—that certain actions lead to certain reactions.

- They learn about changes in objects and materials. For instance, how mixing, heating, or cutting will produce changes in materials and that some changes are reversible and some are irreversible.
- They begin to understand that objects not in motion are in a state of balance.

They learn more about force and motion (inanimate objects are set in motion; pushing and pulling put objects in motion; objects can move in different ways).

1.0 Properties and Characteristics of Nonliving Objects and Materials

At around 48 months of age	At around 60 months of age
1.1 Observe, investigate, and identify the characteristics and physical properties of objects and of solid and nonsolid materials (size, weight, shape, color, texture, and sound).	1.1 Demonstrate increased ability to observe, investigate, and describe in greater detail the characteristics and physical properties of objects and of solid and nonsolid materials (size, weight, shape, color, texture, and sound).

2.0 Changes in Nonliving Objects and Materials

At around 48 months of age	At around 60 months of age
2.1 Demonstrate awareness that objects and materials can change; explore and describe changes in objects and materials (rearrangement of parts; change in color, shape, texture, temperature).	2.1 Demonstrate increased awareness that objects and materials can change in various ways. Explore and describe in greater detail changes in objects and materials (rearrangement of parts; change in color, shape, texture, temperature).
2.2 Observe and describe the motion of objects (in terms of speed, direction, the ways things move), and explore the effect of own actions (e.g., pushing, pulling, rolling, dropping) on making objects move.	2.2 Demonstrate an increased ability to observe and describe in greater detail the motion of objects (in terms of speed, direction, the ways things move), and to explore the effect of own actions on the motions of objects, including changes in speed and direction.

Teachers can support children's development of the foundations of the physical sciences through the following:

- Provide children with opportunities to explore a variety of objects and materials in the daily environment.
- Prepare yourself and be purposeful about the scientific concepts children will investigate while engaged with objects and materials.
- Engage children in projects that allow them to explore, experiment, and invent with objects and materials for an extended period of time.
- Experiment with materials and objects before offering them to children.
- Invite children to observe and describe the characteristics and physical properties of the objects and materials they investigate.
- Plan opportunities for children to sort and classify objects and materials and reflect on similarities and differences.
- Provide children with opportunities to build and experiment with simple machines. Simple machines refer to six mechanical devices that make it easier to move or lift something: levers, a wheel on an axle, a pulley, an inclined plane, a wedge, and a screw.
- Provide children with opportunities to investigate the form and function of different tools and machines.
- Avoid presenting children with activities of "magical" science (such as chemical "snow" and exploding volcanoes) that are done for entertainment purposes and with the children as observers (not participants).
- Select activities or projects in which children can vary their actions on objects and observe the immediate reactions to their actions.
- Use cooking activities as opportunities to reason about transformations in materials.
- Invite children to set up an experiment and collect and analyze data.
- Focus children's attention on the effect of one aspect (variable) at a time.
- Lead children to make predictions about what they expect to happen.
- Ask questions to raise children's awareness of how they produced an effect.
- Encourage children to record and document investigations with objects and materials.[5]



Figure 4.3: There is science at play when making tamales.[6]

Vignettes

Ms. Yen introduced children to a variety of solid materials, including feathers, wood chips, pennies, foam pieces, marbles, and eggshells. After the materials were introduced, she left them for children's free exploration in the discovery center. The center also included tools such as magnifiers, trays, cups, and a balance scale to expand their observations of the materials, and the children were familiar with how to use them. Children enjoyed exploring these materials, especially finding out how they are similar or different from each other. One question they investigated was, "Which materials are rigid and which are soft?" Children tried pressing, poking, twisting, tearing, and breaking the different materials and shared their conclusions with their classmates as they worked: "The pennies are hard." "The feathers are very soft. You can bend them, and they do not break." "The eggshell breaks when you press on it, and these (points to foam pieces) are soft, and you can break them like this (the child demonstrates how they break easily)." "The wood chips are very hard, too." With the teacher's assistance, some children recorded their findings on the chart, by gluing a sample of each material under "Rigid" or "Soft."

During the last cooking activity Ms. Moreno noticed that the children were fascinated when they mixed the flour with water. The children's reactions gave Ms. Moreno an idea for extending the group's explorations with dry materials and engaging them in exploring mixtures. In small-group time, Ms. Moreno introduced the children to different dry materials, such as salt, flour, cornstarch, and sugar, and invited them to explore them. She then suggested that they mix some of these materials with water. The teacher asked the children questions to invite them to make predictions: "What do you think will happen if we add salt to water . . ." As the children watched the salt crystals disappear, they discovered that when salt is mixed with water, it cannot be seen anymore. The teacher immediately asked questions that encouraged the children to check their predictions. Ms. Moreno asked the children, "What happened when you stirred the salt in water?" Children came up with different answers: "It disappears." "It is inside the water, but you cannot see it anymore." Ms. Moreno invited the children to taste plain water and the water stirred with salt, and tell the difference. When the children communicated that they tasted the salt and that it was still in the water, the teacher introduced the word dissolve to the children and explained that the salt dissolved in water to make salt water. The children tried out different materials and discovered that some dissolve in water and others, such as flour or sand, do not. The next day, the children tried mixing other materials such as glue, lemonade powder, tea leaves, and play dough to find out what happens to each of these materials when mixed with water.

The children were playing at the water table and taking turns tossing an object into the water, to find out which objects sink and which objects float. Ms. Schultz held a plastic cup, and asked, "What do you predict will happen to this cup when you put it in the water? Will it sink or float?" David said, "It will float like the other cup," referring to the Styrofoam cup they tested earlier. Dana said, "It will sink because it is more hard than the white cup." Gaby said, "Maybe if we put it in like this (facing up), it will not sink." Ms. Schultz asked, "Why do you think so?" Gaby said, "Because the water will not go inside." She put the cup in the water, facing up, and the children observed the cup floating. "You see! It is floating." David said, "Now, let's put it in like this (facing down)." Ms. Shultz said, "That's a great idea. Let's put the cup in the water facing down and see what happens. What is your prediction? Will the cup sink or float?"

The children predicted that the plastic cup will float again. Ms. Shultz asked, "Why do you think it will float?" David answered, "Because it was floating before." She put the cup in the water, facing down, and everyone, including Ms. Schultz,

was surprised when they saw the cup sinking in the water. The children were fascinated with what they discovered. They kept putting the cup in the water, one time facing up and one time facing down, watching it turn from a “floater” to a “sinker.”[7]

Pause to Reflect

How can different interest areas in the preschool environment (e.g., the block area, the water table, the sensory table, and the playground) be used to enhance children’s explorations of objects and materials?

Supporting Life Sciences

Life sciences for young children are about nurturing children’s curiosity and fascination with the natural world and building their understanding and appreciation of living things. Preschool children have various opportunities to engage with living things in their preschool environment. When playing in the yard, they may come across small animals or bugs or notice changes in the trees. They may help take care of the class pet or plants in the room. They participate in different planned activities related to living things, such as going on a neighborhood walk to collect different leaves, search for bugs or other small animals in the yard, sort and classify fruits and vegetables, explore various seeds, plant bulbs, sprout seeds, or grow a garden. Such experiences in the preschool environment can provide the context for rich experiences of scientific inquiry about properties and characteristics of living things.

The goal is to provide children with opportunities which allow them to closely observe living things, including human beings, and to encourage them to question, explore and investigate physical characteristics, behaviors, habitats, and needs. Through ongoing opportunities to observe and discuss what they have seen, children develop their ideas about living things, how they are the same, and how they differ from one another. They start to sort and classify and look for patterns. They begin to recognize commonalities such as the physical structure and basic needs of different living things, but also the diversity and variation among different organisms.



Figure 4.4: Classrooms can get a butterfly kit to experience the life cycle of butterflies[8]

The teacher has an important role in guiding children through experiences of exploring and observing animals and plants around them, whether outdoors, as they exist in nature, or indoors in an environment that is as natural as possible. They deepen children’s understanding of living things, including features of their own body parts and processes, by encouraging children to observe closely, raise questions, investigate more about a topic, describe and represent their observations, and by creating opportunities for discussion and reflection. At the same time, they model wonder and excitement of the natural world and an attitude of respect for living things and their habitats.

Key Concepts in Life Sciences

In studying animals, plants, and humans, children develop an understanding of key concepts related to living things such as:

- All living things have basic needs that must be met for them to grow and survive.
- The body parts of living things are useful for them in meeting their needs.
- The physical characteristics of living things reflect how they move and behave.
- Living things have their habitats in different environments.
- All living things grow over time and go through changes related to the life cycle.

There is variation and diversity in living things

1.0 Properties and Characteristics of Living Things

At around 48 months of age	At around 60 months of age
1.1 Identify characteristics of a variety of animals and plants, including appearance (inside and outside) and behavior, and begin to categorize them.	1.1 Identify characteristics of a greater variety of animals and plants and demonstrate an increased ability to categorize them.
1.2 Begin to indicate knowledge of body parts and process (e.g., eating, sleeping, breathing, walking) in humans and other animals.	1.2 Indicate greater knowledge of body parts and processes (e.g., eating, sleeping, breathing, walking) in humans and other animals.
1.3 Identify the habitats of people and familiar animals and plants in the environment and begin to realize that living things have habitats in different environments.	1.3 Recognize that living things have habitats in different environments suited to their unique needs.
1.4 Indicate knowledge of the difference between animate objects (animals, people) and inanimate objects. For example, expect animate objects to initiate movement and to have different insides than inanimate objects.	1.4 Indicate knowledge of the difference between animate and inanimate objects, providing greater detail, and recognizing that only animals and plants undergo biological processes such as growth, illness, healing, and dying.

2.0 Changes in Living Things

At around 48 months of age	At around 60 months of age
2.1 Observe and explore growth and changes in humans, animals, and plants and demonstrate an understanding that living things change over time in size and in other capacities as they grow.	2.1 Observe and explore growth in humans, animals, and plants and demonstrate an increased understanding that living things change as they grow and go through transformations related to the life cycle (for example, from a caterpillar to butterfly).
2.2 Recognize that animals and plants require care and begin to associate feeding and watering with the growth of humans, animals, and plants.	2.2 Develop a greater understanding of the basic needs of humans, animals, and plants (e.g., food, water, sunshine, shelter).



Figure 4.5: Children can help plant, maintain, and harvest from a garden.^[9]

Teachers can support children's development of the life sciences foundations with the following:

- Focus children's explorations on key concepts of living things
- Take children on outdoor explorations of plants and animals.
- Model curiosity and interest in nature
- Remind children to be respectful of nature
- Engage children in conversations about what they notice and point their attention to important aspects of living things
- Document children's outdoor explorations
- Provide children with tools for explorations of living things
- Include plants and animals indoors
- Engage children in close observations of living things (animals, plants, and fruits and vegetables)

- Invite children to share in-home experiences with living things
- Use books to enrich and extend children's study of living things
- Provide children with opportunities to care for plants and animals
- Provide children with opportunities to observe and monitor plants' growth and development
- Engage children in reflective conversations in small or large groups
- Involve families in children's planting and gardening experiences
- Provide children with opportunities to observe changes and transformations in animals passing through stages of the life cycle
- Provide children with opportunities to observe changes and transformations in animals passing through stages of the life cycle
- Discuss the death of living things from the scientific perspective of death, and explain to them that all living things die (families should be informed of the discussions to be prepared to answer questions).
- Invite children to investigate their own growth[10]

Vignettes

While playing outdoors, Gregory pointed up to the oak tree and shouted, "Look, a squirrel up in the tree." Joanna whispered, "Shhh . . . You will scare the squirrel away." They stood there silently, watching the squirrel. Soon more children joined them. Ms. Leon, watched them observing the squirrel and asked, "What do you think the squirrel is doing?" (Pause) "What do you think he is looking for?" She listened carefully to the children's ideas and questions while observing the squirrel: "It is climbing up." "He is looking at us." "I think he is looking for something to eat." Joanna asked Ms. Leon, "Is that where he lives?" Ms. Leon turned the question right back to her and asked, "What do you think?" Ms. Leon expected this question to come up because recently they were talking about the habitats of different animals and commented that some animals live in trees. Later, during group time, Ms. Leon invited children to share with the group their observations of the squirrel. She brought up her question again: "What do you think the squirrel was looking for in the tree?" Some children said that squirrels were looking for food. Ms. Leon asked, "What kind of food do you think squirrels may find in the tree?" Joanna suggested, "Maybe they eat leaves." Miguel said, "Maybe the squirrel was looking for seeds." Ms. Leon answered, "Oh, so you think that squirrels may eat leaves, nuts, and seeds. Let's get our small binoculars and journals and observe the squirrels to find out what squirrels are doing in the tree and what they like to eat.

The teacher cut open the avocado, and Danny got really excited. "I knew there was going to be a big seed inside." Ms. Wilson replied, "You did predict that there was going to be a big seed inside." She invited children to observe the inside of the avocado. Rena said, "It has this thing inside." Sara pointed to the empty half and said, "This is where it was." The teacher replied, "It is the avocado seed." She took out the seed and handed it to Rena. "Oh, it is slippery." Ms. Wilson put it on a tray and said, "It does feel very slimy." She invited children to observe the seed. "What does it look like? What does it feel like?" After she gave children time to observe the avocado seed, she pointed to the other fruits in the basket and said, "I wonder if these fruits are also going to have seeds inside. What do you think?" Rena said, "Maybe the orange will not have very big seeds." Danny said, "The avocado has a big seed inside, not the orange." Ms. Wilson asked, "What do you think is inside the orange?" The teacher invited the children to predict what kind of seeds are inside an orange, a mango, a butternut squash, a papaya, and a plum and wrote down their predictions. She then invited the children to cut open the fruits and check what was inside[11]

Pause to Reflect

How can you find out what ideas, interests, cultural beliefs, or fears the children in your group bring to their study of living things?

Supporting Earth Sciences

When children play with dirt, jump in puddles, collect rocks, observe the rain, or feel the heat of the sun, they have direct contact with aspects of the earth. Daily interactions and direct contact with objects and earth events provide children with the context to observe and explore properties of earth materials and to identify patterns of change in the world around them (for example, patterns

of day and night, and changes in temperature). With teachers' guidance, children's everyday interactions and direct contact with objects and earth events can become rich, inquiry based experiences of earth sciences.



Figure 4.6: Exploring outdoors helps connect children with nature.^[12]

Teachers can provide children with opportunities to explore the physical properties of earth materials and to observe, record, and track changes in the weather and how it affects the living world. Exploratory interactions with earth materials and ongoing observations of earth phenomena enhance children's connection to nature and raise their awareness of the importance of caring for and respecting the natural world. The box below summarizes key concepts in earth sciences. The following section provides practical strategies to engage children in rich, focused explorations of earth materials and phenomena.

Key Concepts in Earth Sciences

In studying earth materials and phenomena, children become aware of key characteristics of earth:

- Earth materials (soil, sand, rocks, air, water) are part of the natural environment.
- Earth materials have different properties.
- There are patterns of change in earth phenomena (day/night; seasons). Natural objects in the sky (sun, moon) are not always in the same place.
- Temperature and weather changes can be tracked over time.
- Weather and seasonal changes affect the environment.

People should respect and care for the environment.

1.0 Properties and Characteristics of Earth Materials and Objects

At around 48 months of age	At around 60 months of age
1.1 Investigate characteristics (size, weight, shape, color, texture) of earth materials such as sand, rocks, soil, water, and air.	1.1 Demonstrate increased ability to investigate and compare characteristics (size, weight, shape, color, texture) of earth materials such as sand, rocks, soil, water, and air.

2.0 Changes in the Earth

At around 48 months of age	At around 60 months of age
2.1 Observe and describe natural objects in the sky (sun, moon, stars, clouds) and how they appear to move and change.	2.1 Demonstrate an increased ability to observe and describe natural objects in the sky and to notice patterns of movement and apparent changes in the sun and the moon.
2.2 Notice and describe changes in weather.	2.2 Demonstrate an increased ability to observe, describe, and discuss changes in weather.
2.3 Begin to notice the effects of weather and seasonal changes on their own lives and on plants and animals.	2.3 Demonstrate an increased ability to notice and describe the effects of weather and seasonal changes on their own lives and on plants and animals.
2.4 Develop awareness of the importance of caring for and respecting the environment and participate in activities related to its care.	2.4 Demonstrate an increased awareness and the ability to discuss in simple terms how to care for the environment, and participate in activities related to its care.

Teachers can support children's development of the earth science foundations with the following:

- Take children on a search for earth materials in nature
- Invite children to observe, compare and classify earth materials
- Invite children to explore and experiment with earth materials
- Use opportunities to explore earth materials in the context of studying living things or when exploring other solid and nonsolid materials
- Invite children to share in-home experiences with earth materials
- Engage children in observing and describing the sun and the moon and other natural objects in the sky
- Provide children with opportunities to observe, record, and discuss the weather
 - Develop an awareness of the daily weather
 - Invite children to record and discuss changes in the weather
 - Invite children to observe and discuss the effects of weather and seasonal changes on their life and the environment around them
 - Engage families in children's explorations of weather and seasonal change
- Model and discuss respect for the environment
- Engage children in caring for and protecting the environment through everyday routines in the preschool environment
- Collect and use recycled materials[\[13\]](#)

Vignettes

Ms. Tina observes the children playing at the sandbox. Ted fills up the bucket with water and pours it on the sand. Olivia and Ted watch as the water is absorbed by the sand. Next they begin to pile the sand into a mound. Olivia says, "It's like a mountain. Let's make it bigger." They add more sand and compact it together. Their mountain is beginning to take shape and gets bigger and bigger. Olivia says, "I am going to get water." She gets a small bucket and gently pours it on top of the mountain. She notices how the water creates a depression in the sand and then flows down. Ted says, "Like a river." He gets more water in the bucket and pours it again in the same place. The depressed part gets bigger. Ms. Tina gets closer and asks, "What happens when the water is flowing down your mountain?" Ted describes, "The water makes a hole in the mountain. Olivia says, "It takes the sand down." Ms. Tina said, "A little bit of water at the beginning helped to hold the mountain together, but pouring a large amount of water causes the sand to slip and slide away. It can also happen in nature, when water breaks down the land."

Today, Rena's father came to school to share with the group some of his kites and to build a kite with the children. First, he invited the children to observe him flying one of his kites in the air, and then the children took turns flying the kite together with him. After they came inside, Rena's father asked the children, "So what do you think makes the kite fly up?" Children came up with different answers. "The wind touches the kite all around, and it goes up in the sky. It pushes the kite up, up, up,

up in the sky.” Another child said, “The air goes through the holes of the kite, and it moves the kite to the sky.” Rena’s dad invited children to notice the shape of the kite, and together they discovered that the kites he brought have a similar shape, “like a diamond.” He also asked them why they think the kite needs to be light and not heavy, and one of the children said, “Because it needs to fly up.” Rena’s dad told them, “A long time ago, kites were invented in China. People used bamboo sticks and silk to make kites.” He then invited children to build a kite. “Now we are going to build our own kite. What do you think we need to build a kite?”

Every month the children observe the oak tree outdoors and keep records of how it changes from month to month. Ms. B. encourages children to make drawings of the tree, and together with the children, she takes photos of it once a month. While observing the tree, Ms. B invites them to share their observations: “What changes do you see?” “Why do you think the tree changed like that?” Through such discussions, Ms. B helps children to begin to draw the connection between the changes they observe in the tree and the changes in the weather and seasons. In the fall, children collected fallen oak acorns and leaves. They were fascinated with its deeply lobed leaves, and some of them made drawings of the oak leaves in their journals. They also observed the acorns and talked about them as well as other trees around the yard that have dry fruit similar to the acorn. Ms. B creates a class book with the observational drawings, children’s words, and photographs documenting the changes the children observe each month. By the end of the school year, the book will include their documentation of the tree in order of the seasons: fall, winter, spring, and summer.^[14]

References

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CHAPTER OVERVIEW

5: Early Math Experiences

5.1: Importance of Early Childhood Mathematics and Developing Number Sense

5.2: Number and Operations

5.3: Shapes and Spatial Relations

5.4: Comparison and Patterning

5.5: Measurement

5.6: Data Analysis

5.7: Standards

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5.1: Importance of Early Childhood Mathematics and Developing Number Sense

Course Competency 5. Examine strategies that teach early math skills

Criteria 5.1. describe the continuum of number and counting development.

Introduction to Mathematics

In this chapter, you'll explore the importance of early math education, and best teaching practices in early childhood mathematics. You will be introduced to the joint position statement from the NCTM and NAEYC on early mathematics. You'll discover the mathematical strands and how we can support children develop skill and understanding of this content.



Math Learning Starts Early

“Mathematical knowledge begins during infancy and undergoes extensive development over the first 5 years of life. It is just as natural for young children to think mathematically as it is for them to use language, because “humans are born with a fundamental sense of quantity” (Geary, 1994, p. 1), as well as spatial sense, a propensity to search for patterns, and so forth” (Clements, Sarama, & DiBiase, 2004).

Emergent mathematics is the earliest phase of development of mathematical and spatial concepts. Emergent mathematics encompasses the skills and attitudes that a child develops in relation to math concepts throughout the early childhood period. Emergent mathematics and those foundational math skills are not optional. They are necessary to the success of each and every student.

It is widely accepted that literacy learning begins the day a child is born. Reading to infants and toddlers and preschoolers is an early predictor of positive literacy success. Mathematical understanding can be regarded in the same way. During the first months of life, a child begins to construct the foundations for mathematical concepts. For example, before a child can count, he/she can construct ideas about mathematics. They recognize “more,” “less,” and basic equality.

Read the articles, “[Early Math Skills Predict Later Academic Success](#)” by Nancy Christensen. You will notice that early childhood mathematics is critical for the future success of children (Duncan, 2007). As you read this article, reflect on what you have learned, what difference it makes to you as a future teacher and the children you will teach, and what you can do with this information.

✓ Research Highlight

Research indicates that the ability to reason about numbers starts as early as infancy. Five-month-olds show sensitivity to the effects of addition or subtraction of items on a small collection of objects. Toddlers viewing three balls put into a container and then one being removed know to search for a smaller number of balls, and many search for exactly two balls.

By the time children are in preschool, prior to having any formal lesson in arithmetic, they use a variety of strategies to solve simple addition and subtraction problems. They may use manipulatives or fingers to represent the numbers in the problem and count out loud to find out the answer. As they get older, they rely less and less on finger counting. To solve an addition problem such as $4 + 2$ presented with concrete objects (e.g., color crayons), the child may count all objects “one, two, three, four” and

then continue with the second set of objects “five, six” and find out there are a total of six. At a later stage, the child may “count on” from the second set of objects. Knowing the number of objects in the first set (e.g., “four”), the child starts with “four” and continues to count “five, six” to find out the total number of objects, rather than starting to count from “one” with the second set of objects.^[3]

Source:

K. Wynn, “Addition and Subtraction by Human Infants,” *Nature* 358 (1992): 749– 50.

P. Starkey, “The Early Development of Numerical Reasoning,” *Cognition* 43, no. 2 (1992): 93–126.

R. S. Siegler, “The Perils of Averaging Data Over Strategies: An Example from Children’s Addition,” *Journal of Experimental Psychology: General* 116, no. 3 (1987): 250–64.

Best Teaching Practices

As a teacher of mathematics, please remember these fundamental beliefs.

1. Thinking about the problem, not just the answer, is what is most important. The teacher should be the facilitator, not the one with all the answers.
2. Process is more important than product. Mathematics is not just “facts” to be memorized. The concepts children learn are of utmost importance; and then the memorization will come. Children must have experiences through play and using manipulatives and “reinvent” the concepts of mathematics in their own minds.

The National Council of Teachers of Mathematics (2014), in its publication [Principles to Action](#), represents a unified vision of what is needed for teaching all students.

The **Eight Mathematics Teaching Practices** can be found in the [Executive Summary](#).

1. Establish mathematics goals to focus learning.
2. Implement tasks that promote reasoning and problem-solving.
3. Use and connect mathematical representations.
4. Facilitate meaningful mathematical discourse.
5. Pose purposeful questions.
6. Build procedural fluency from conceptual understanding.
7. Support productive struggle in learning mathematics.
8. Elicit and use evidence of student thinking.

Read more about the Mathematics Teaching Practice in the [Executive Summary](#).

Treat Children as Mathematicians

- Mathematicians often work for an extended time on a single problem. Allow your students ample time to work on a problem.
- Mathematicians collaborate with their colleagues and study the work of others. Allow your students to collaborate, argue, consult, defend, ask, explain, and pose questions to others.
- Mathematicians must prove for themselves that their solution is correct. Children must also prove to themselves that they have the correct solution. Give students time to think and discuss. Don’t be too quick to tell a student their answer is correct or incorrect; instead ask the student to explain their answer.
- The problems mathematicians work on are complex. Good problems ask students to find innovative solutions without a time limit. Problems should spark children’s thinking, rather than promote rote memorization.
- Mathematicians get satisfaction from the problem-solving process and take pride in their solutions. Children will understand the concepts and procedures more if they are allowed to use their own thinking processes. This also allows children to make connections to prior knowledge and real-life experiences.
- Mathematicians use unsuccessful attempts as stepping-stones to solutions. We need to emphasize mathematical thinking rather than just getting the correct answer.

NCTM/NAEYC Position Statement on Early Start in Learning Mathematics

The National Council of Teachers of Mathematics (NCTM) and the National Association for the Education of Young Children (NAEYC) published a [Joint Position Statement](#) (2010) affirming high-quality, challenging, and accessible mathematics education for 3- to 6-year-old children is a vital foundation for future mathematics learning. The ten research-based, essential recommendations to guide your classroom practice are:

1. Enhance children's natural interest in using mathematics to make sense of their world.
2. Build on children's background experience and knowledge.
3. Base instruction on knowledge of children's cognitive, linguistic, physical, and social-emotional development.
4. Strengthen children's problem-solving and reasoning processes as well as representing, communicating, and connecting mathematical ideas.
5. Ensure a coherent curriculum that is compatible with sequences of important mathematical ideas.
6. Provide for children's deep and sustained interactions with mathematical ideas.
7. Integrate mathematics with other activities and other activities with mathematics.
8. Provide ample time, materials, and teacher support for children to engage in play where they explore mathematical ideas.
9. Use a range of experiences and teaching strategies to introduce mathematical concepts, methods, and language.
10. Support children's learning by thoughtful and continuous assessment.



Allow children to work for long periods of time on one problem. Good problems can have multiple solutions and different ways to arrive at those solutions; therefore, allow children to use their own methods for solving a given problem. Children's excitement about mathematics comes from their own thinking abilities; encourage social interaction that promotes children to act as young mathematicians by requiring them to prove their answer and all the steps they took to attain the answer. Additionally, allow children to be wrong many times before being right. It is important to encourage children to see "wrong" answers as a natural part of mathematical processes.

Mathematical Strands

Mathematical strands are the different domains or areas of mathematics knowledge. The Wisconsin Model Early Learning Standards has divided this knowledge into 6 areas. You will see the areas reflected in the standards below.

- B. EL. 1** Demonstrates an understanding of numbers and counting.
- B. EL. 2** Understands number operations and relationships.
- B. EL. 3** Explores, recognizes, and describes, shapes and spatial relationships.
- B. EL. 4** Uses the attributes of objects for comparison and patterning.
- B. EL. 5** Understands the concept of measurement.
- B. EL. 6** Collects, describes, and records information using all senses.

(Please note B.EL.1 and B.EL.2 refer to skills and knowledge in number sense. Some states keep those two components together, but Wisconsin has organized this knowledge into 2 separate standards.)

You will explore each of the strands throughout the chapter, starting with Number Sense below.

Number Sense

The earliest mathematical skills children develop deal with number recognition (identifying and naming numbers) and counting. Both are part of the foundational mathematic skill of number sense. (Refers to **B. EL. 1** Demonstrates an understanding of numbers and counting.)

Number sense is defined as a “good intuition about numbers and their relations. It develops gradually as a result of exploring numbers, visualizing them in a variety of contexts, and relating them in ways that are not limited by traditional algorithms” (Howden, 1989). When students consider the context of a problem, look at the numbers in a problem, and make a decision about which strategy would be most efficient in each particular problem, they have number sense. Number sense is the ability to think flexibly between a variety of strategies in context.

Building on subitizing, composing and decomposing numbers, using ten-frames, and the hundreds chart will help develop number sense in your students. When students have number sense, they gain **computational fluency**, are **flexible** in their thinking, and are able to choose the most efficient strategy to solve a problem. (Refers to **B. EL. 2** Understands number operations and relationships.)

Number sense is a foundational idea in mathematics; it encourages students to think flexibly and promotes confidence with numbers. According to Marilyn Burns (2007), “students come to understand that numbers are meaningful and outcomes are sensible and expected.” And “just as our understanding of phonemic awareness has revolutionized the teaching of beginning reading, the influence of number sense on early math development and more complex mathematical thinking carries implications for instruction” (Gersten & Chard, 1999).

Number sense is a skill that allows students to work with numbers fluently and efficiently. This includes understanding skills such as quantities, concepts of more and less, symbols represent quantities (8 means the same thing as eight), and making number comparisons (12 is greater than 9, and three is half of six). Students must

1. Understand numbers, ways of representing numbers, relationships among numbers, and the number system,
2. Understand the meanings of operations and how they related to one another, and

Compute fluently and make reasonable estimates (NCTM, 2000).

Teachers must give students many opportunities to develop number sense through activities with physical objects, such as counters, blocks, or small toys. Most children need that concrete experience of physically manipulating groups of objects. After these essential experiences, a teacher can move to more abstract materials such as dot cards and ten frames. These materials would help to develop the more complex aspects of Number Sense represented in Wisconsin Model Early Learning Standard **PERFORMANCE STANDARD: B.EL. 2 Understands number operations and relationships.**

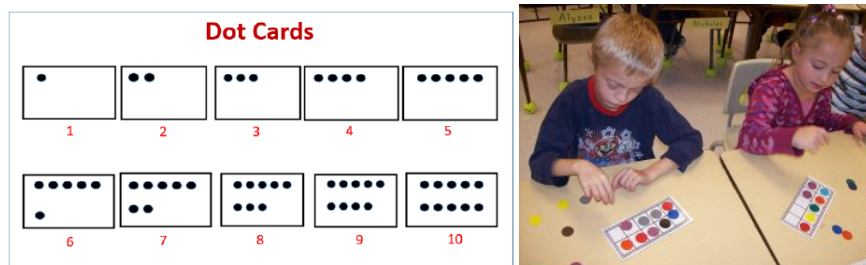




Figure 9.5: These children are exploring numbers and quantity as they play with dominos.[2]

The Development of Counting Skills/Number Sense

See the chart below to see how counting skills develop in young children.

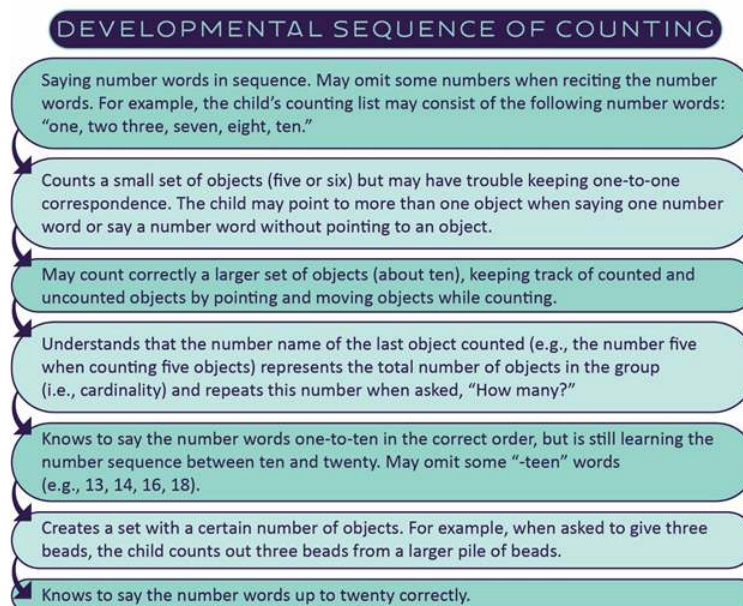


Figure 9.5: Image by Ian Joslin is licensed by [CC-BY-4.0](https://creativecommons.org/licenses/by/4.0/)

The information below is from the California Preschool Standards and is again provided as a reference to the age you may see these Number Sense skills appear. However, remember the Wisconsin Model Early Learning Standards include the skills for Number Sense in order of development but do not assign a specific age to any skills as all children develop at their own rate and time.

Examples in 1.0 would correlate to WMELS **B.EL. 1 Demonstrates understanding of numbers and counting.**

At around 48 months of age	At around 60 months of age
1.0 Children begin to understand numbers and quantities in their everyday environment.	1.0 Children expand their understanding of numbers and quantities in their everyday environment.
1.1 Recite numbers in order to ten with increasing accuracy.	1.1 Recite numbers in order to twenty with increasing accuracy.
1.2 Begin to recognize and name a few written numerals.	1.2 Recognize and know the name of some written numerals.
1.3 Identify, without counting, the number of objects in a collection of up to three objects (i.e., subitize).	1.3 Identify, without counting, the number of objects in a collection of up to four objects (i.e., subitize).
1.4 Count up to five objects, using one-to-one correspondence (one object for each number word) with increasing accuracy.	1.4 Count up to ten objects, using one-to-one correspondence (one object for each number word) with increasing accuracy.
1.5 Use the number name of the last object counted to answer the question, “How many . . . ?”	1.5 Understand, when counting, that the number name of the last object counted represents the total number of objects in the group (i.e., cardinality).

Teachers can support children’s development of the number sense foundations with the following:

- Observe children’s spontaneous counting and foster growth through scaffolding or modeling
- Encourage counting during everyday interactions and routines
- Include preschool children’s home language in counting activities, whenever possible
- Ask questions that encourage purposeful counting
- Foster one-to-one correspondence within the context of daily routines (such as setting the table)
- Support preschool children’s ability to apply the counting procedure by
 - Providing a lot of objects to count
 - Starting with small sets
 - Modeling counting
 - Encouraging children to self-correct their counts
- Consider adaptations for children with special needs
- Use games, books, and other materials accessible to preschool children
- Plan group activities focused on counting
- Promote the use of comparison terms (more, same as, fewer, or less) through everyday interactions
- Use everyday interactions and routines to illustrate and discuss addition and subtraction transformations (“adding to” results in more and “taking away” results in less)
- Make estimations
- Use graphing with children[3]



Figure 9.6: Here is an example of a material that supports children’s understanding of Arabic numerals and counting.[4]

Supporting the Development of Number Sense Through Songs and Fingerplays

We know signing songs and participating in fingerplays is a great way to develop language skills in young children, but it is also a way to develop important concepts relating to number sense. See the Erikson Institute Early Math Collaborative for more

information on [Songs and Fingerplays](#) with preschoolers to develop their number sense. Also, see their other resources to learn more about [number sense](#) and [counting](#).

Giving children multiple opportunities to experience early number concepts and number sense is critical for early childhood teachers.

Children must experience mathematics through play and manipulatives as they make sense of numbers in their own minds.

Math Milestones



Children grow faster in the first two years of life; more than at any other period of development. During the first two years, the brain grows from 25% of its adult weight to 75% of its final adult weight. Additionally, gross motor skills develop; they use large muscle groups to crawl, sit, stand, and lift things. Fine motor skills develop more slowly: stacking blocks, stringing beads, zipping zippers, and buttoning buttons.

Children are learning about the world around them through experiencing it through sight, smell, sound, touch, and taste. They are also learning by thinking about things, forming hypotheses, testing them, and problem solving. This is Piaget's sensorimotor stage of development. This stage is from birth to approximately 2 years of age, and is a period of rapid cognitive growth and development. [Object permanence](#) is the main development during the sensorimotor stage and is vital to mathematics because it is the understanding that an object continues to exist even if it is not seen. According to Geist, "object permanence is the first step toward representation. When a child knows something exists even when he can't see it, it means he has a mental concept of the object in the absence of its presence. This is one of the bases upon which more advanced mathematics will be built. Numbers are representative of objects and quantities even if we do not see them" (Geist, 2009).

At a very early age, babies use mathematics concepts to make sense of their world. For example, they can signal "more" when they want more food. In addition, they know the difference between familiar and unfamiliar adults which is "sorting and classifying." They have "spatial reasoning" as they play with boxes of different sizes, and they use "patterns" as they say words and phrases.

As early as 6 months old, children begin to develop an understanding of "more." They ask for "more milk" or "more food." Babies from 0-12 months begin to predict the sequence of events, such as running water means bath time, they begin to classify things into certain categories, such as toys that make noise and toys that don't, and they begin to understand relative size, such as parents are big and babies are small (Morin, 2014).

At 12 to 18 months old, children start to recognize patterns and understand shapes as they play with objects. They begin to sort familiar objects by characteristics, and they enjoy filling and emptying containers. Many children at this age can complete simple puzzles when the puzzle pieces show the whole object.

Although each child progresses at different levels, generally children of 18 months to 24 months old can show "one" and "two" on their fingers. They know some number words. Although they do not understand quantity, they do begin to understand "take one" or "give me one." Children can match same-sized shapes. Puzzles and toys of squares, triangles, and circles help children develop spatial reasoning.

At 24 to 30 months old, children are learning important mathematical concepts and skills through their play. They recognize patterns and begin to use logical reasoning to solve everyday problems. They can sort shapes and stack blocks by size, and be able to distinguish between "big and small" and "fast and slow." Children will be able to say some numbers, although they may skip

some numbers in the sequence. For example, they may say, “one, two, three, five, ten...” By the age of 3, children should be able to count one to ten. Children at this stage of development generally understand addition and subtraction with the numbers one and two.

At approximately three years old, a child may attend a preschool. But what does mathematics teaching and learning look like in a preschool classroom? All children have the potential to learn mathematics that is challenging and at a high-level (Sarama & Clements, 2009). There is a wide range of development between ages three and five. There will be children who are “almost potty trained” as well as children who have begun learning to read. “Sit-and-listen” approach is only effective if it is highly engaging and exciting, for example, a story being read to the class. Therefore, teaching should consist almost entirely of “active learning.” Teaching should emphasize student-directed/teacher-facilitated activities. Worksheets are inappropriate at this level.

At 3-4 years old, children can count up to 30; and be able to count backwards from ten. Additionally, they can use [ordinal numbers](#) “first,” “second,” and “third.” At this age, children will be able to use superlatives such as “big, bigger, biggest.” At age 4, children will understand the concept of addition as putting together and subtraction as taking from when objects are in front of them. They also recognize shapes, begin to sort things by color, shape, size, or purpose, understand that numerals stand for numbers, and have the spatial awareness to complete puzzles (Morin, 2014).

At age four, children begin to have [one-to-one correspondence](#) in which numbers correspond to specific quantities. For example, a child would point to the number of blocks on the table and say, “1, 2, 3, 4, 5. I have five blocks.”

At age five, children can identify the larger of two numbers and recognize numerals up to 20. They can copy or draw shapes, and understand basic time concepts such as days of the week. By age six, children can add and subtract within ten mentally and solve simple word problems.

Read more about Mathematical Milestones: [Children’s Development of Mathematical Concepts: Ages 0-4 \(Infants, Toddlers, & Preschoolers\)](#).



Infants and Toddlers

Mathematics is all around us! And we use mathematical language all the time, even without realizing it. For example, when we sort laundry into colors and whites, we are sorting and classifying. Keeping score at a game is number and operations. Spatial relationships occur when we give someone directions, and when we make comparisons such as big and little, that is measurement. Everyday activities include patterns and order. Teachers must make mathematics visible to children through math talks (Greenberg, 2012).

Infants and toddlers understand number and operations as we talk with them about numbers, quantity, and one-to-one correspondence. According to Greenberg (2012), we can say the following to young children:

- You have two eyes, and so does your bear. Let's count: 1-2.
- I have more crackers than you do. See, I have 1, 2, 3, and you have 1, 2. I'm going to eat one of my crackers. Now I have the same as you!
- That's the third time you have said mama. You've said mama three times!

Infants and toddlers understand geometry by recognizing and naming shapes. According to Greenberg (2012), we can talk with our children about understanding shapes and spatial relationships:

- Look, Samantha went under the stool and Hartley is on top.
- You are sitting next to your sister.
- Some of the cookies are square and some are round.

Algebraic thinking begins as children see patterns, relationships, and change as they recognize relationships that make up a pattern or create repetitions. For example, you can say to infants and toddlers:

- Grandpa has stripes on his shirt – red, white, blue, red, white, blue.
- Let's clap to the beat of this song.
- I put the blocks in the bucket; you dump them out. I put the blocks back in the bucket; you dump them out.

Data analysis begins as infants and toddlers gather, sort, classify, and analyze information to make sense of their world. Teachers can talk with children about data by saying the following:

- Let's put the big lid on the big bowl.
- You always smile when mommy sings.

Adapted from Greenberg, 2012

Math talks begin as soon as a child is born. During bath time, diaper time, meal time, or on walks or shopping trips is the perfect time to talk about shapes and sizes, talk about patterns, and describe things that are different. Mathematics comprehension is more than just numbers. Math is also about sorting things into categories such as big, bigger, and biggest; solving problems using patterns; solving spatial problems; and using logic.

Read more about Math Talks with infants and toddlers in this article, [More, All Gone, Empty, Full: Math Talk Every Day in Every Way](#).

Kindergarten and First Grade

As children enter kindergarten and first grade, there are many changes in the physical, cognitive, and social-emotional development. Children in kindergarten can sit and attend to a formal lesson for approximately 10 minutes. At this level, the focus of mathematics instruction should be through experiences. By first grade, children can sit for a 15-20 minute formal lesson and although they are developing selective attention (the ability to decide what to attend to and what to ignore), the focus should still be on mathematics teaching through experiences.

Children in kindergarten and first grade are developing their gross and fine motor skills. According to Thelen and Smith, the development of coordination comes from physical play such as running and jumping and skipping (Thelen & Smith, 1996). Fine motor skills are developed as children write numbers and letters and use a pencil.

Kindergarteners can add by counting on their fingers, and start with six on the other hand; they can copy or draw symmetrical shapes, and can follow multi-step directions using first and next. In first grade, students can predict what comes next in a pattern, know the difference between two- and three-dimensional shapes, count to 100 by ones, twos, fives, and tens, and can write and recognize numbers, and do basic addition and subtraction up to 20 (Morin, 2014).



The Value of Play

Play does not guarantee mathematical development, but it offers rich possibilities. As the teacher, it is up to you to observe and develop a classroom when children have many opportunities to discover mathematical concepts through play. Douglas Clements says, “Anyone who is pushing arithmetic onto preschoolers is wrong. Do not hurry children.” (Clements, 2001, pg. 270). Mathematics should be about joy and challenges, not pressure and compulsion.

For example, children begin to recognize mathematical patterns by listening to music. They naturally make relationships between different-size and different-shaped blocks by sorting. According to Clements (2001), “Good early mathematics is broader and deeper than mere practice in counting and adding. It includes debating which child is bigger and drawing maps to ‘treasure’ buried outside. Quality mathematics instruction includes providing loads of unit blocks, along with loads of time to use them; asking children to get just enough pencils for everyone in the group; and challenging children to estimate and check how many steps are required to walk to the playground.”

Classrooms that offer children opportunities to engage in play-based learning activities help children grow not only academically. “Play is a particular attitude or approach to materials, behaviors, and ideas and not the materials or activities or ideas themselves; play is a special mode of thinking and doing” (McLane, 2003, p. 11). As discussed in an earlier chapter, there is a strong connection between early mathematics learning and later success. One determining factor of later achievement is quality early mathematical experiences.

Play is critical to a young child’s learning. Mathematics activities must be developmentally appropriate by “integrating logical thinking, decision making comparison, and the making of relationships throughout the child’s day into everything they do” (Geist, 2009). This is the goal of emergent mathematics – to immerse children in mathematics, number, and number concepts. Mathematics at this level must be taught through experiences. Engaging young children in play-based learning, teachers can include the following:

- Rhythm and music allows children to recognize mathematical patterns,
- Blocks and shapes gives children opportunities to make relationships between them, such as same and different,
- Everyday activities such as counting help children develop number concepts,
- Manipulatives such as stringing beads, multicolored balls, blocks, etc. encourage children in imaginative play,
- Everyday routines and common activities such as snack time or distributing plates and napkins, and
- Math games encourage children to make mathematical relationships.

Adapted from Geist, 2009

Read the article, “[Mathematics in the Preschool](#)” by Douglas H. Clements for more information about quality early mathematical experiences.

Watch the video, “[The Decline of Play](#),” by Peter Gray.

Play is how children learn! Mathematics games, fantasy play, puzzles, manipulatives, and games allow children to learn and grow.

As you read the vignettes below think about how number sense is being developed and fostered.



Vignettes

Playing with cars on the rug, a child argued, “I have more: one, two, three, seven, nine, ten.” His friend replied, “No, I have more: one, two, three, four, five, six, seven.” The teacher intervened and asked, “How do you think we can find out who has more cars?” “I count,” said one of the children. The teacher suggested, “Let’s count together,” and she modeled counting together with the children. She put the cars in each set, in a row, and lined up the two sets against each other. The teacher pointed to each car while counting.

During snack time, Veronica asked: “Can I have two more crackers?” The teacher replied, “Yes, and I see you already have two crackers. When I give you two more, how many crackers will you have altogether?”[5].

The Teacher's Role in Math

Mathematics is a natural part of the preschool environment. Young children actively construct mathematical knowledge through everyday interactions with their environment, whether inside or outside.

Mathematics learning grows naturally from children’s curiosity and enthusiasm to learn and explore their environment. During the preschool years, children continue to show a spontaneous interest in mathematics and further develop their mathematical knowledge and skills related to number, quantity, size, shape, and space. Teachers should encourage children’s natural enthusiasm and interest in doing mathematics and use it as a vehicle for supporting the development of children’s mathematical concepts and skills.

High-quality mathematics education in preschool is not about elementary arithmetic being pushed down onto younger children. It is broader than mere practice in counting and arithmetic. It is about children experiencing mathematics as they explore ideas of more and less, count objects, make comparisons, create patterns, sort and measure objects, and explore shapes in space. Mathematics learning happens throughout the day, and it is integrated with learning and developing in other developmental domains such as language and literacy, social-emotional, science, music, and movement. There is a general consensus “that high-quality, challenging and accessible mathematics education for three- to six-year-old children is a vital foundation for future mathematics learning.”

Teachers have a significant role in facilitating children’s construction of mathematical concepts. When teachers join children in becoming keen observers of their environment and in reasoning about numbers, shapes, and patterns, mathematics is enjoyable and exciting for all.



Figure 9.2: Songs and games are fun ways to support math.[2]

Teachers may not always realize the extent to which their current everyday classroom practices support children’s mathematical development. For example, when singing with children “Five Little Ducks Went Out One Day,” incorporating finger play with counting, the teacher develops children’s counting skills and understanding of numbers. Discussing with children how many children came to school today and how many are missing supports children’s arithmetic and reasoning with numbers. Playing with children in the sandbox by filling up different cups with sand and discussing which cup is the smallest or the largest or how many cups of sand it would take to fill up a bucket introduces children to concepts of comparison and measurement.[3]

References

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5.2: Number and Operations

Course Competency 5. Examine strategies that teach early math skills.

5.2. identify concepts of number operations.

Number and Operations

Number and Operations is a part of Number Sense. Strong number sense is highly related to later mathematical development. Both Wisconsin Model Early Learning Standards B.El.1 and B.El.2 align with Number Sense.

We can think of **B.El. 1 Demonstrates understanding of numbers and counting** as the beginning or more basic concepts involved with Number Sense such as imitating counting, rote counting, one-to-one correspondence, and recognizing and writing numerals.

B.El. 2 Understands number operations and relationships deals with more complex concepts in Number Sense such as comparing quantities, subitizing, more and less, adding (combining sets), and subtraction (removing from sets).

Please see the Wisconsin Model Early Learning Standards for Mathematical Thinking to review the standards, developmental continuum and sample behaviors of adults.

The information below is from the California Preschool Standards and is again provided as a reference to the age you may see these Number and Operations skills appear. However, remember the Wisconsin Model Early Learning Standards include the skills for Number Sense in order of development but do not assign a specific age to any skills as all children develop at their own rate and time.

Examples in 2.0 would correlate to WMELS **B.El. 2 Understands number operations and relationships**

At around 48 months of age	At around 60 months of age
2.0 Children begin to understand number relationships and operations in their everyday environment.	2.0 Children expand their understanding of number relationships and operations in their everyday environment.
2.1 Compare visually (with or without counting) two groups of objects that are obviously equal or nonequal and communicate, "more" or "same."	2.1 Compare, by counting or matching, two groups of up to five objects and communicate, "more," "same as," or "fewer" (or "less").
2.2 Understand that adding to (or taking away) one or more objects from a group will increase (or decrease) the number or objects in the group.	2.2 Understand that adding one or taking away one changes the number in a small group of objects by exactly one.
2.3 Understand that putting two groups of objects together will make a bigger group.	2.3 Understand that putting two groups of objects together will make a bigger group and that a group of objects can be taken apart into smaller groups.
2.4 Solve simple addition and subtraction problems nonverbally (and often verbally) with a very small number of objects (sums up to 4 or 5).	2.4 Solve simple addition and subtraction problems with a small number of objects (sums up to 10), usually by counting.

Supporting the Development of Number and Operations

TEN FRAME



Created by Sarah Carter | @mathequalslove | mathequalslove.net | **M + A + T + H = Love**

Another way to develop number sense and the more complex skills involved with number and operations in children is to use ten-frames. A “ten-frame” is a rectangle, separated into two rows, with 10 equal spaces. Here is a [blank ten-frame](#) from NRICH.

Ten-frames help students develop number sense, a sense of ten, and learn basic number facts. A ten-frame also gives students a visual of numbers, of composing and decomposing numbers, and is a good way to teach addition and subtraction within 10.

This [Ten Frame applet](#) from NCTM Illuminations is a fun way for students to practice counting and addition skills.

Hundreds Chart

A Hundreds Chart is essential in every K-2 classroom. Ask students what patterns they see on the Hundreds Chart. You can also begin to “hide” numbers on the Hundreds Chart and ask students to tell what that number is and how they know. See [Math, Kids and Chaos](#) to learn what a hundreds chart is and how to use one.

100 Chart

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

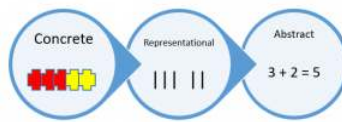
Whole Number Computation



Computational fluency is the ability to accurately, efficiently, and flexibly compute with basic operations (National Research Council, 2001) and is developed over time. In elementary school, students learn about the four basic operations, the properties of the operations, and the strategies to perform those operations. It is developed progressing from concrete models to drawings and then to symbols. The **Concrete Representational Abstract** (CRA) approach helps students make the connection from concrete manipulatives to abstract mathematical ideas. The three stages of learning mathematics are:

- **Concrete** – students physically manipulate objects to solve a mathematics problem
- **Representational** (or semi-concrete) – involves using images to represent objects.
- **Abstract** (or symbolic) – using only numbers and symbols to solve math problems.

In preschool, we would mostly be working with Concrete and then Representational. Older children would work with Abstract computations once they enter school. However, some children with advanced mathematical abilities may be able to complete abstract or symbolic computations sooner.



CRA is grounded in the constructivist theory of learning. Teachers begin with concrete manipulatives, transition to visual representations/drawings, and then move to abstract mathematical numbers and symbols. When teaching students addition and subtraction, begin with models/manipulatives, and then progress to bar diagrams, and number lines.

Watch the video from Graham Fletcher, “[The Progression of Addition and Subtraction.](#)”

Addition and Subtraction Computation

In kindergarten, students developed an understanding of addition as putting together and adding to, and subtraction as taking apart and taking from. Students in first grade are expected to add two-digit numbers to one-digit numbers; and in second grade, students add two- and three-digit numbers. It is important to note that the traditional algorithms are not required until fourth grade. Therefore, students are expected to compose and decompose numbers and use flexible methods to solve problems.

When adding two or more numbers, the result is the **sum**. The **symbol used for addition** is the plus sign (+). The inverse of addition is **subtraction**, and the result is called the **difference**. The symbol used for subtraction is the minus sign (-).

First grade students will extend their number facts and place value strategies to add within 100. Do not introduce the traditional addition or subtraction algorithms in first grade. Instead, represent a problem using words, numbers, pictures, manipulatives, and/or symbols.

Estimation

Don’t teach estimation by asking students “make a guess.” The word “estimate” comes from the Latin word aestimare, which means to value. To estimate means to judge the value of something, and an estimate is the resulting calculation. A “guess” is to form an opinion with little or no evidence. When you tell students to make a guess, they are making uninformed conclusions. On the other hand, estimating means to make an informed decision based on data and models (Nichol, n.d.).

Vignettes

The children cleaned up the play yard before going back inside. The teacher, Ms. Denise, had noticed that not all the shovels were picked up from the sandbox. Ms. Denise asked for help saying, “We need all five shovels back in the box so our toys aren’t lost. I see here only three. We need more shovels in the box. How many more shovels do we need?” The teacher had noticed that Ling Wa, one of the older preschool children in the group, was counting her fingers, trying to find out how many shovels were missing.

Ling Wa suddenly said, “Ms. Denise, we need two more.”

Ms. Denise went further, asking, “Do you think we need two more shovels?” How did you figure that out?”

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5.3: Shapes and Spatial Relations

Course Competency 5. Examine strategies that teach early math skills.

5.3. describe shapes and spatial relationships.

Geometry sounds like a complex topic to introduce to young children. However, the basic foundations of geometry are introduced in the early childhood years.

Supporting Geometry

Geometry is the study of shapes and spatial relationships. Children enter preschool with a strong intuitive knowledge about shapes, spatial location, and transformations. They learn about geometry as they move in space and interact with objects in their environment. From infancy they begin to form shape concepts as they explore their environment, observe shapes, and play with different objects. Before they can name and define shapes, very young children are able to match and classify objects based on shape. During the preschool years, children develop a growing understanding of shape and spatial relationships. They learn the names of shapes and start to recognize the attributes of two- and three-dimensional shapes. They also develop an understanding of objects in relation to space, learning to describe an object's location (e.g., on top, under), direction (e.g., from, up, down) and distance (e.g., near, far).



<https://dpi.wi.gov/sites/default/files/imce/fscp/pdf/ec-wmels-rev2013.pdf>

Figure 9.11: By using their bodies to make a triangle these children are working with shapes and spatial understanding. [13]

Please see the Wisconsin Model Early Learning Standards for Mathematical Thinking to review the standards, developmental continuum and sample behaviors of adults.

The information below is from the California Preschool Standards and is again provided as a reference to the age you may see these geometry related skills appear. However, remember the Wisconsin Model Early Learning Standards include the skills for Shapes and spatial relationships in order of development but do not assign a specific age to any skills as all children develop at their own rate and time.

Examples in 1.0 and 2.0 would correlate to WMELS **B.EL. 3 Explores, recognizes, and describes shapes and spatial relationships**

At around 48 months of age	At around 60 months of age
1.0 Children begin to identify and use common shapes in their everyday environment.	1.0 Children identify and use a variety of shapes in their everyday environment.
1.1 Identify simple two-dimensional shapes, such as a circle and square.	1.1 Identify, describe, and construct a variety of different shapes, including variations of a circle, triangle, rectangle, square, and other shapes.
1.2 Use individual shapes to represent different elements of a picture or design.	1.2 Combine different shapes to create a picture or design.
2.0 Children begin to understand positions in space.	2.0 Children expand their understanding of positions in space.
2.1 Identify positions of objects and people in space, such as in/on/under, up/down, and inside/outside.	2.1 Identify positions of objects and people in space, including in/on/under, up/down, inside/outside, beside/between, and in front/behind.

Teachers can support children’s development of the geometry foundations with the following:

- Refer to shapes and encourage the use of shape names in everyday interactions
- Engage preschool children in conversations about shapes, including both
 - Two-dimensional shapes (such as circles, squares, and triangles)
 - Three-dimensional shapes (such as spheres, cubes, and cones)
- Provide materials that encourage preschool children to explore and manipulate shapes in space
- Include books, games, and other learning materials with shape-related themes in the preschool environment
- Provide preschool children with playful opportunities to explore and represent shapes in a variety of ways
- Present preschool children with many different examples of a type of shape
- Provide materials and equipment to promote spatial sense
- Support preschool children’s spatial sense in everyday interactions
- Provide preschool children with planned experiences to promote the understanding of spatial sense, including
 - Songs and games
 - Books
 - Construction opportunities[14]



Figure 9.12: Building with pattern blocks such as these, promotes geometry.[15]

Vignettes

The teacher had noticed that several children in her group had shown a strong interest in castles. They built castles in the block area, in the sandbox, and even looked for castles in fairy tale books when visiting the library. The teacher suggested that the group build a big castle outside. They started by gathering the materials. The children brought from home different sized boxes and figures or characters to be included in the castle. The teacher also offered big cylinders, cones, building blocks, construction boards, and other materials. The children made different suggestions: “Put all the big boxes here and the small ones on top of them.” “I put it above this for the roof.” “We can use these for the tower.”

The teacher described their ideas using names of shapes and spatial terms. “So you want to put the small square blocks on top of the big rectangle blocks.” “Are you suggesting using the cylinders to build the tower?” The children enjoyed building the structure, using different shapes and materials, and were proud of it.

During circle time, the teacher invited children to describe the castle and how it was built. “Look at the castle you built. Can you tell me what it looks like?” Children were encouraged to use spatial words and the names of shapes in their talk. The activity evolved into a long-term project. The children kept adding more pieces to the s

Geometry is a branch of mathematics that studies the sizes, shapes, positions, and dimensions of things. “Geometric and spatial thinking are important in and of themselves, because they connect mathematics and the physical world... and because they support the development of number and arithmetic concepts and skills” (Progressions for the Common Core State Standards in Mathematics, 2013). The Progressions document goes on to say,

“learning geometry cannot progress in the same way as learning number, where the size of the numbers is gradually increased and new kinds of numbers are considered later. In learning about shapes, it is important to vary the examples in many ways so that students do not learn limited concepts that they must later unlearn. From Kindergarten on, students experience all of the properties of shapes that they will study in Grades K–7, recognizing and working with these properties in increasingly sophisticated ways. The Standards describe particular aspects on which students at that grade level work systematically, deeply, and extensively, building on related experiences in previous years” (Progressions for the Common Core State Standards in Mathematics, 2013).

Former NCTM President J. Michael Shaughnessy said, “If algebra is the language of mathematics, geometry is the glue that connects it” (Shaughnessy, 2011). Additionally, geometry “covers the skills and concepts of visualization, spatial reasoning and representation, and analyzing characteristics and properties of two- and three-dimensional shapes and their relationships” (Lappan, 1999). In the Kansas Mathematics Standards, geometry spans every grade level from kindergarten to grade eight; it first begins with [spatial sense](#), an intuition about shapes and the relationships between them including an ability to recognize, visualize, represent, and transform geometric shapes.

Van Hiele Levels for Teaching Geometry

The development of geometric thinking comes from Pierre van Hiele and Dina van Hiele-Geldof. The van Hieles identified five levels of geometric thinking through which students pass. Most elementary students are at levels 0 or 1 and some middle school students are at level 2. The levels are developmental – children of any age begin at level 0 and progress to the next level through experiences with geometric ideas (Van de Walle, Karp, Bay-Williams, 2019).

Level 0: Visualization

Students begin by recognizing shapes by their whole appearance, but not exact properties. For example, students see a door as a rectangle or a clown’s hat as a triangle, but may not be able to recognize the shape if it is rotated. The emphasis at Level 0 is on shapes that students can observe, feel, build/compose, or take apart/decompose. The goal of Level 0 is to explore how shapes are alike and how they are different and use these ideas to create classes of shapes (Van de Walle, Karp, Bay-Williams, 2019).

Level 1: Analysis

At this level, students start to learn and identify parts of figures and can describe a shape’s properties. Additionally, students at this level understand that shapes in one group have the same properties. For example, students know that parallelograms have opposite sides that are parallel and can talk about the properties of all parallelograms, not just this one. Students at Level 1 use physical models and drawing of shapes and use the properties of shapes such as symmetry, classification, and congruent sides and angles.

Level 2: Informal Deduction/Abstraction

Students at Level 2 start to recognize the relationship between properties of shapes and develop relationships between these properties. Students will consider if-then reasoning, such as “If all four angles are right angles, the shape must be a rectangle. If it is a square, all angles are right angles. If it is a square, then it must be a rectangle.” Level 2 includes informal logical reasoning and should be encouraged to ask “Why?” or “What if?” Additionally, Level 2 tasks emphasize logical reasoning.

Level 3: Formal Deduction

At this level, students analyze informal arguments and are capable of more complex geometric concepts. A student at this level is usually in high school.

Level 4: Rigor

The last level of geometric reasoning is the ability to compare geometric results in different axiomatic systems; they see geometry in the abstract. A student at this level is usually a college mathematics major.

Read this short article from [NRICH](#) for some activities required at each of the levels of geometric thinking.

In order to support students as they move from a Level 0 to a Level 1, teachers should focus on the following:

- Focus on the properties of shapes rather than the identification of those shapes,
- Challenge students to test their ideas about shapes using a variety of examples, and
- Provide multiple opportunities for students to draw, build, make, compose, and decompose shapes.



Shapes and their Properties

Students should first focus on the location and position of shapes in order to develop a variety of skills that will contribute to their spatial thinking. In kindergarten, students are expected to describe the position of shapes in the environment using the terms above, below, beside, in front of, behind, and next to. Additionally, students develop spatial sense by connecting geometric shapes to their everyday lives and shapes in their environment.

Students must have experience with a variety of two- and three-dimensional shapes. Additionally, triangles should be shown in several forms and not always with the vertex at the top or the base horizontal with the bottom of the paper (Van de Walle, Karp, & Bay-Williams, 2019).

Kindergarten students learn to describe shapes by their attributes and should be given multiple opportunities to build physical models. When students build and manipulate shapes, they can learn to explore and describe the number of sides and corners (vertices). Ask students to describe shapes by the properties, such as “squares have four sides of equal length.”

Two-dimensional shapes

It is in kindergarten that students learn to distinguish between two- and three-dimensional shapes. Two-dimensional shapes are flat and can be measured in only two ways such as length and width. Examples of two-dimensional shapes are squares, circles, triangles, etc.

Classifying shapes begins in kindergarten. And when students sort and classify polygons, they should determine the groupings, not the teacher. In second grade, students focus on triangles, quadrilaterals, pentagons, and hexagons. Third grade students think about the subcategories of quadrilaterals, and by fifth grade, they “understand the attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category.” For example, a square is a rectangle and a square is also a rhombus.

Composing and Decomposing

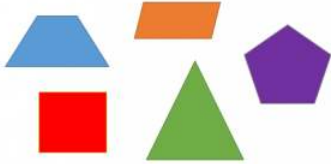
Students need multiple opportunities to explore how shapes fit together to form larger shapes (compose) and how larger shapes can be made of smaller shapes (decompose). In kindergarten, students move beyond identifying and classifying shapes to creating new shapes using two or more shapes. This concept is foundational to students’ development of translation (move or slide), rotation, and reflection (flip). Children can first be exposed to many of these concepts while playing in the block area.

In first grade, students compose and decompose plane figures and determine which attributes are [defining](#) and [non-defining](#). Defining attributes are those properties that help to define a shape, such as the number of angles, number of sides, length of sides, etc. Non-defining attributes are properties that do not define a shape such as color, location, position, etc. An example is a square.

All squares must be closed figures and have 4 equal sides and all angles 90°; these are defining attributes. Squares can be different colors and be turned in a different direction; these are non-defining attributes.

Example:

Which of the following is a square? And how do you know?



- A square has 4 sides.
- All four sides are the same length.
- All angles are 90 degrees.
- Therefore, the red figure is a square.

Be sure to give students many opportunities with a variety of manipulatives to explore and build shapes. These manipulatives could be paper shapes, pattern blocks, color tiles, tangrams, or geoboards with colored rubber bands (or you can use [virtual geoboards](#)).

When students are composing and decomposing both plane and solid figures, they are also building an understanding of part-whole relationships and compose and decompose numbers. Furthermore, it is in first grade that students partition regions. Students need multiple opportunities to use the words halves, fourths, and quarters, which is critical to understanding fractions. In second grade, students work with halves, thirds, fourths; and teachers will help students make the connections that a whole is two halves, three thirds, or four fourths.

In third grade, students partition shapes into equal portions. For example, partition a square into four equal parts.



Each of the above squares are partitioned into fourths, and each part has the same area.

Three-dimensional shapes

Kindergarten students learned to distinguish between two- and three-dimensional shapes. Three-dimensional shapes have three dimensions, such as height, width, and depth. Examples of three-dimensional shapes are [cubes](#), [prisms](#), [rectangular prisms](#), [pyramids](#), etc. Additionally, it is important to note that the faces of three-dimensional shapes can be named as specific two-dimensional shapes. Give students multiple opportunities to work with pictorial representations, concrete objects, and technology as they develop their understanding of both two and three-dimensional shapes.

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5.4: Comparison and Patterning

Course Competency 5. Examine strategies that teach early math skills.

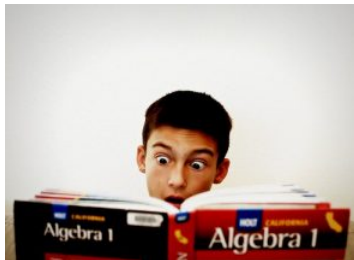
5.4. use attributes and objects for comparison and patterning.

Algebraic Thinking

Pause to Reflect

Before reading this section, did you think that algebra was something that should be considered in the preschool classroom? Why or why not?

As with Geometry, one might think Algebra is too difficult of a subject for young children. However, early skills in comparison, patterning, and explaining thinking when combining sets (addition) or decomposing sets (subtraction) lay a strong foundation for algebraic thinking." The Wisconsin Model Early Learning Standard that aligns most closely with Algebraic Thinking is **B.EL. 4 Uses the attributes of objects for comparison and patterning.**



What is algebraic thinking?

As you read the Kansas Mathematics Standards, you will notice the Domain “Operations and Algebraic Thinking” in all grade levels preK grade 12. Furthermore, algebraic thinking and concepts permeate all areas of mathematics. Algebra is more than manipulating symbols or a set of rules, **it is a way of thinking**. When looking at the [Wisconsin Standards for Mathematics](#), you will also see that standards for Algebraic Thinking are present in all grade levels K-12.

According to the [K-5 Progression on Counting & Cardinality and Operations & Algebraic Thinking](#) (2011), algebraic thinking begins with early counting and telling how many in a group of objects, and builds to addition, subtraction, multiplication, and division. Operations and Algebraic Thinking is about **generalizing arithmetic** and **representing patterns**.

Algebraic thinking includes the ability to

recognize patterns,

represent relationships,

make generalizations,

and analyze how things change.

In the early grades, students notice, describe, and extend patterns; and they generalize about those patterns.



Completing puzzles in preschool can indirectly relate to algebraic thinking by fostering foundational skills that are important for later mathematical concepts. Here's how:

1. **Pattern Recognition:** Many puzzles require children to identify and match patterns. This skill is fundamental in algebra, where recognizing patterns in numbers and operations is crucial.
2. **Problem-Solving:** Solving puzzles encourages critical thinking and problem-solving skills. These skills are transferrable to algebra, where students must analyze problems and develop strategies to find solutions.
3. **Spatial Reasoning:** Some puzzles, especially geometric puzzles, enhance spatial reasoning abilities. Spatial reasoning is important in algebraic thinking, especially when dealing with graphs and spatial representations of mathematical concepts.
4. **Logical Thinking:** Puzzles often require logical thinking and deduction. This logical approach is valuable in algebra, where students must follow logical steps and rules to solve equations and problems.

While completing puzzles directly addresses skills like pattern recognition and problem-solving rather than specific algebraic concepts, these foundational skills play a role in preparing children for more advanced mathematical thinking, including algebra, as they progress through their education. (OpenAI. (2024, May 10). Completing puzzles in preschool can indirectly relate to algebraic thinking [Response to "Does completing puzzles in preschool relate to algebra?"]. OpenAI. <https://openai.com>)

Connecting Number and Operations and Algebraic Thinking

Kindergarten

Students in kindergarten solve addition and subtraction problems in various ways as they make sense of and understand the concepts of addition and subtraction. Kindergarten students should see addition and subtraction equations, and should be encouraged to write equations, such as $4 + 3 = 7$ and $7 - 3 = 4$, but do not require this of students at this level. It is critical that students see the relationship between numbers, and teachers need to provide students those experiences to manipulate numbers using objects, drawings, mental images, etc. so that students can progress from the concrete, to the pictorial, to the abstract levels.

Preschool

Preschool teachers can connect number and operations to algebraic thinking in several ways:

1. **Pattern Recognition:** Introduce children to patterns in numbers and shapes. For example, use simple sequences like 1, 2, 3, 4, and encourage children to predict the next number. This lays the groundwork for understanding number sequences and algebraic patterns later on.
2. **Problem-Solving with Numbers:** Present age-appropriate word problems that involve basic addition and subtraction. Encourage children to use strategies like drawing pictures or using objects to solve these problems. This helps develop problem-solving skills, which are essential in algebra.
3. **Exploring Equality:** Teach children about the concept of equality using balance scales or visual representations. For instance, show that $2 + 3$ is equal to 5 and explore different ways to represent this equation (e.g., $3 = 5 - 2$). This introduces the idea of balancing equations, a fundamental concept in algebra.
4. **Introduce Variables:** Introduce the concept of variables using simple symbols (e.g., using a star "*" to represent an unknown quantity). Encourage children to solve problems where they need to find the value of the variable, such as in simple equations like $3 + * = 5$.

5. ****Use Concrete Manipulatives:**** Utilize physical objects like blocks or counters to represent numbers and operations. This hands-on approach helps children understand abstract concepts by making them more tangible and relatable.
6. ****Encourage Mathematical Discussions:**** Foster discussions about mathematical concepts during group activities or circle time. Ask open-ended questions that promote critical thinking and reasoning, such as "How do you know that $2 + 2$ is equal to 4?"
7. ****Incorporate Math into Everyday Activities:**** Find opportunities to integrate math into daily routines, such as counting during snack time or incorporating math concepts into storytelling or games.

By incorporating these strategies into their teaching practices, preschool teachers can effectively bridge the gap between number and operations and the foundational concepts of algebraic thinking, setting a strong foundation for future mathematical learning. (OpenAI. (2024, May 10). How preschool teachers can connect number and operations to algebraic thinking [Response to "How can preschool teachers connect number and operations to algebraic thinking?"]. OpenAI. <https://openai.com>)

Supporting Algebra and Functions (Classification and Patterning)

Obviously, preschool is not the time to teach traditional algebra, but this is the period when foundational algebraic concepts evolve and gradually develop. Children observe the environment and learn to recognize similarities and differences. They learn to sort, group, and classify objects. They learn to recognize ordering relations, such as large to small, and to identify patterns. They develop the ability to make predictions, form generalizations, and derive rules.



Figure 9.7: As she built this tower, this young girl made a pattern with the colors red and blue.[6]

The information below is from the California Preschool Standards and is again provided as a reference to the age you may see these algebraic thinking skills appear. However, remember the Wisconsin Model Early Learning Standards include the skills for comparison and patterning in order of development but do not assign a specific age to any skills as all children develop at their own rate and time. The standards for Wisconsin emphasize that children should develop skills in categorizing, matching, sorting, using positional words, and patterning. See [WMELS B.EL. 4 Uses the attributes of objects for comparison and patterning](#)

Examples in 1.0 and 2.0 would correlate to WMELS B.EL. 4 Uses the attributes of objects for comparison and patterning.

At around 48 months of age	At around 60 months of age
1.0 Children begin to sort and classify objects in their everyday environment.	1.0 Children expand their understanding of sorting and classifying objects in their everyday environment.
1.1 Sort and classify objects by one attribute into two or more groups, with increasing accuracy.	1.1 Sort and classify objects by one or more attributes, into two or more groups, with increasing accuracy (e.g., may sort first by one attribute and then by another attribute).
2.0 Children begin to recognize simple, repeating patterns.	2.0 Children expand their understanding of simple, repeating patterns.
2.1 Begin to identify or recognize a simple repeating pattern.	2.1 Recognize and duplicate simple repeating patterns.
2.2 Attempt to create a simple repeating pattern or participate in making one.	2.2 Begin to extend and create simple repeating patterns.

Teachers can support children's development of the algebra and functions foundations with the following:

- Organize the classroom into different categorized storage areas to facilitate classification
- Include materials and objects for sorting in the environment
- Identify opportunities for sorting and classifying in everyday routines
- Recognize and extend sorting in play
- Plan for children at different levels
- Integrate sorting into children's current topic of interest and study
- Point out patterns in the environment
- Engage preschool children in conversations about patterns
- Play with patterns in various formats such as
 - Objects
 - Movement
 - Sounds
 - Rhymes and stories[7]



Figure 9.8: Providing sets of materials in different colors sets up natural opportunities for classification and grouping. [8]

Vignettes

As part of a curriculum unit on the seasons, the children went for a nature walk and collected various types of leaves. During the walk and later in the classroom, the children explored the leaves and were encouraged to describe different attributes of the leaves such as shape (pointy, round, long, needle), size (small, tiny, wide, big), color (red, green, yellow, orange, brown) and texture (smooth, soft, hard, wet, dry, rough). Children were then asked by the teacher to sort the leaves: "Put leaves that belong together in groups."

The teacher asks Enrique, "Why did you put these leaves together and those leaves together?" Enrique responds, "They are same." The teacher asks, "How are these the same?" Enrique points and says in Spanish, "Café aquí, amarillo aquí, y hojas rojas." ("Brown here, yellow, here, and red leaves here."). The teacher points to each group of leaves and says in English, "Great! Brown, yellow, and red leaves. What other ways can we sort the leaves? How about putting all the big leaves here and all the small ones there?" The teacher models for the child, sorting leaves by size. "Where do you think this leaf would go?"

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5.5: Measurement

Course Competency 5. Examine strategies that teach early math skills.

CRITERIA 5.5. identify concepts of measuring and estimating.

Measurement



Figure 5.1: When measuring two cups of flour, $\frac{1}{2}$ cup of salt, two tablespoons of oil to help make playdough, children use and build their mathematical knowledge.^[1]

Measurement is the “assignment of a numerical value to an attribute of an object” (NCTM, 2000). Measurement is a critical concept in mathematics because of the connection to everyday life. Additionally, there are connections to other mathematics, as well as other content areas.

Supporting Measurement

The Measurement strand involves comparing, ordering, and measuring things. Included in this strand is the child’s ability to compare and order objects by length, height, weight, or capacity; to use comparison vocabulary; and to begin to measure. Young children develop an intuitive notion of measurement through natural everyday experiences. They explore and discover properties such as length, height, volume, and weight as they look for a longer block, measure who is taller, pour sand from a small bucket to a larger one, or try to pick up a heavy box and ask for help. They make comparisons to see which is longer, taller, heavier, larger, or smaller.



Figure 5.2: Tools such as this balance can help children compare weight.^[9]

The information below is from the California Preschool Standards and is again provided as a reference to the age you may see these measurement related skills appear. However, remember the Wisconsin Model Early Learning Standards include the skills for measurement in order of development but do not assign a specific age to any skills as all children develop at their own rate and time. See [WMELS](#) for specific behaviors of children and strategies of adults for measurement.

At around 48 months of age	At around 60 months of age
1.0 Children begin to compare and order objects.	1.0 Children expand their understanding of comparing, ordering, and measuring objects.
1.1 Demonstrate awareness that objects can be compared by length, weight, or capacity, by noting gross differences, using words such as <i>bigger</i> , <i>longer</i> , <i>heavier</i> , or <i>taller</i> , or by placing objects side by side to compare length.	1.1 Compare two objects by length, weight, or capacity directly (e.g., putting objects side by side) or indirectly (e.g., using a third object).
1.2 Order three objects by size.	1.2 Order four or more objects by size.
<i>This box intentionally left blank</i>	1.3 Measure length using multiple duplicates of the same-size concrete units laid end to end.

Teachers can support children’s development of the measurement foundations with the following:

- Provide opportunities to promote measurement concepts in the environment (things to measure and measure tools)
- Observe preschool children’s measurement concepts in everyday play and routines
- Facilitate and reinforce measurement concepts in everyday play and routines by
 - Building the descriptive and comparative vocabulary
 - Asking questions to bring their attention to the measurable properties of objects
 - Challenging them to use measurement to solve problems
- Provide opportunities to compare and order objects
- Use literature to illustrate measurement concepts
- Provide small-group activities using standard and nonstandard measurement
- Encourage estimations of measurement
- Encourage recording and documentation of measurements[10]



Figure 5.3: This boy is measuring the boulder with a yardstick[11]

✓ Vignettes

As part of exploring and learning the concept of growth, the children have planted sunflower seeds in the garden. A long stick was attached to each plant, and the teacher asked that every week the children mark on the stick the height of the sunflower. Tracking the growth of sunflowers has generated comparison and measurement experiences. For example, one week the teacher pointed to one of the sunflowers and explained to the children, “Last week when we measured this sunflower, it was up to here. It was seven inches long. This week it is up to here. How many more inches do you think it grew in the past week? What is your estimate?”

Children were encouraged to make estimates and then were invited to measure the growth of this sunflower. “How can we measure how much it has grown since last time?” Children had different ideas. Some children said, “You need a ruler.” Others said, “With this” and pointed to a measuring tape. Over time, children were also comparing the sunflowers one to another. On one occasion, the teacher helped a small group of children compare the height of two flowers by using a string to represent the height of one flower and then laying the string against the second flower.

Children enjoyed tracking the sunflowers’ growth and finding out, “Which sunflower is taller?” and “Which is taller?”—the child or the sunflower.[12]

Other Forms of Measurement

Reading a Clock

Students typically don't learn to read a clock until 1st grade. Students in grades 1-3 learn to read a clock (analog and digital); in first grade, they tell time to the nearest hour and half hour, in second grade, to the nearest 5 minutes, and in third grade, to the nearest minute. In third grade, students solve problems involving elapsed time.



Time can be a difficult subject to teach because it can not be seen or manipulated. Additionally, time is difficult to comprehend for most students because the duration of time depends on what the student is waiting for. However, students in preschool can categorize and sequence time, and use language associated with time. Teachers should give students opportunities to time events in their everyday lives, such as brushing their teeth, eating lunch, riding the bus to school, etc.

Money



Students will begin working with money in second grade and solve word problems involving dollars or cents. Second graders have not been introduced to decimals; therefore, ask students to solve problems involving dollars or cents, but not a combination of the two. They will learn about dollars that include \$1, \$5, \$10, \$20, \$100 bills, and coins that include quarters, dimes, nickels, and pennies. In addition, they should learn to use the \$ and ¢ symbols.

Learning the value of each coin can be confusing for young students because the size of the coin doesn't represent the value. For example, think of a dime and a nickel. The dime's value is 10¢ whereas the nickel's value is 5¢, but the nickel is a bigger coin. Therefore, students need to learn the value of each coin by being told, just as they learn the names of other physical objects.

Preschool students can learn about money through these behaviors stated in the Wisconsin Model Early Learning Standards:

- Child examines both sides of coins using a magnifying glass.
- Child matches and sorts coins by size or denomination.
- Child identifies penny and nickel.
- Child identifies penny and nickel, recognizing that coins have different values by matching five pennies to one nickel.
- Child knows that a nickel is worth more than a penny.
- Child uses coins to give change when playing in the play store or play post office.
- Child pays for an item at the store by counting his/ her money and giving correct amount of change.

Length

There is a recommended sequence for teaching measurement. This begins in preschool and kindergarten by asking students to make comparisons of measurable attributes, such as longer, shorter, taller, heavier, lighter, etc. This is a critical step in the development of measurement. Give students many opportunities to compare directly so the attribute becomes the focus. Additionally, ask students to discuss and justify their answers to questions such as, “Which box will hold the most?” “Which box will hold the least?” “Will they hold the same amount?” “How could you find out?” Provide students with many items to choose from in order to support their thinking, such as dried beans.

Students then continue by using models of measuring units that produce a number called a **measure**. In preschool and kindergarten, start with **nonstandard units**. For example, ask students, “How many snap cubes tall is the can?” or “How many footprints is the length of this room?” A part of the developmental process in the understanding of measurement is the opportunity to measure.

Students should be given opportunities to make or use their own measuring tools, such as paperclips, or a handprint. After students become proficient in making comparisons and measuring with nonstandard units, you can introduce common measuring tools, such as a ruler.

When students make direct comparisons for length, they must notice the starting point of each object and be aware that the objects must be matched up at the end of the object. A developmental milestone for kindergarten students is **conservation of length** which refers to the recognition that moving an object does not change the length.

In first grade, students indirectly measure the length of two objects by using a third object, such as a measuring tool. This is **transitivity** and is connected to conservation. Be sure to use the language taller, shorter, longer, and higher. If students use the words bigger and smaller, ask them to explain what they mean.

When students are measuring an object, they are deciding how many units are needed to fill, cover, or match the object being measured. Ask students to first predict the measurement, then find the measurement, and then discuss the estimates. Additionally, ask students to measure objects that are longer than their measuring tool. This will lead to some good discussions and collaborations among students.

When you ask students to use multiple copies of one object to measure a larger object, this is called **iteration**. Through careful questioning from the teacher, students will recognize the importance of no gaps and overlaps to get a correct measurement.

As students transition from using nonstandard units to standard units to measure, they must be taught to use a ruler correctly when measuring the length of an object. It is critical that students locate the starting point on the ruler. Notice on the ruler below that zero



is not at the end.

You can ask students questions such as, “Do you start at the end of the ruler, or at zero?” and “Why do we start at zero?” and “Are we looking at the spaces or the tick marks?” Students need to understand that the spaces indicate the length of the object; the tick marks indicate the end of the space.

Students also need multiple experiences with measuring in inches, feet, centimeters, and meters. Students should measure a length twice and compare the two measurements. For example, the length of the desk is 36 inches or 3 feet; or the length of a paperclip is 3 centimeters or 30 millimeters.

Students should also be expected to estimate lengths using whole units before they measure. Additionally, students should find their own personal benchmark measurements, such as the width of one of their fingers is a centimeter, or the length between their elbow and wrist is a foot.

Mass and Volume

Beginning in third grade, students will reason about **mass** and **volume**. Students first measure and estimate the liquid volume and masses of objects using grams, kilograms, and liters. Students need multiple opportunities to weigh objects so they have a basic

understanding of the size of weight of a liter, gram, and kilogram. Additionally, students need time to weigh objects and fill containers in order to develop a conceptual understanding of size and weight.

Preschool children can explore measuring mass and volume as they play with balance scales or different-size containers in the sensory table. Providing these play opportunities in preschool helps children to start developing early measurement concepts they will use later in their K-12 math education. of measurements[10]

Pause to Reflect

Involving children in measuring things that are meaningful to them is a great way to engage children in mathematics. Do you remember any measurements experiences from your childhood? This could be formal, like keeping track of your height on a wall or growth chart or measuring the weight and/or length of a fish caught or informal, such as recognizing that a new storage container holds more (volume) or noticing the length difference in a new pair of shoes.

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5.6: Data Analysis

Course Competency 5. Examine strategies that teach early math skills.

CRITERIA 5.6. identify methods of collecting, describing, and recording information.



Data analysis is all around us – in the news or printed in a newspaper or magazine. We all tend to look at the picture/graph, but not think about the analysis of that data. Therefore, our students have experience with the images related to data, but not the analysis. [Data analysis](#) is the processing of data in order to find useful information that will help make decisions.

“Data analysis is a body of methods that help to describe facts, detect patterns, develop explanations, and test hypotheses. It is used in all of the sciences. It is used in business, in administration, and in policy” (Levine, 1997). Data analysis provides numerical results; it finds the number that describes a typical value and finds the differences among numbers; it finds averages. But data analysis is not about the numbers – it uses the numbers to answer questions such as “How does it work?”

There are three “rules” of data analysis. First, we look at the data, think about the data, think about the problem, and ask what it is we want to know. Second, we estimate the [measures of central tendency](#) of the data, and third, we look at exceptions to the central tendency.

Data analysis includes sorting and classifying data, collecting data, and organizing and presenting data. Some examples of data analysis include a tally table, line plot graphs, bar graphs, pictographs, histograms, pie charts, and coordinate grids.

There are two main types of data, [categorical data](#) and [numerical data](#). Categorical data is the type of data that can be put into groups or categories with labels, and describes categories or groups. This is often done according to the characteristics and similarities of the data, such as favorite foods, types of food, or favorite sports. Categorical data can only be placed in one category. Numerical or measurement data is quantitative data that is measurable; such as time, height, weight, amount, etc., or it is a count, such as the number of books a person has.

In kindergarten through grade 5, students mainly focus on categorical data. Specifically, students in kindergarten classify objects into categories; in first grade, students organize and represent categorical data; and in second grade, students draw picture graphs and bar graphs to represent data. Third grade is the most important in the development of categorical data in that students draw picture graphs with each picture representing more than one object, and bar graphs in which the height of each bar is multiplied by a scale factor in order to determine the number of objects in each category.

In grades K-1, students identify and describe measurable attributes. Beginning in second grade, students work with measurement data as they measure lengths. One way to display this data is with a line plot. By the end of fifth grade, students are comfortable with drawing a line plot and analyzing the data so that in sixth grade, students can reason statistically.

Teaching Data and Data Analysis in the Elementary Grades

Students in kindergarten identify and describe the measurable attributes of objects. Students should be given multiple opportunities to describe the attributes. In addition, students should directly compare objects, such as two pencils next to each other in which a student would say, “This pencil is longer.” Be sure when students are making direct comparisons that they pay attention to the starting point and see that the two objects must be lined up at the end. At this grade level, students are recognizing and describing the similarities and differences of measurable attributes, such as longer than, shorter than, taller than, the same size.

As kindergarten students begin to identify the similarities and differences between objects, they use those identified attributes to sort the objects and give the category a name.

The website “[Which One Doesn’t Belong?](#)” is a resource for teachers and students to help students describe attributes of objects.

First grade students can sort a collection of objects, ask questions about the number of objects in each category, and total the number of objects. Then they can compare the number of objects in each category. Students can create graphs and tally charts of real-world situations, such as favorite ice cream, pets, etc.

Teachers must be sure to ask questions about the data in order to provide a foundation for data analysis. For example, students were asked, “What is your favorite pet? Dogs, cats, or hamsters? Students responded and created the chart below.

What is your favorite pet?	
Dogs	12
Cats	8
Hamsters	3

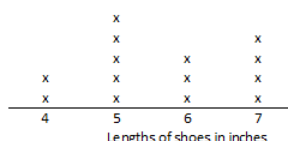
Teachers then need to help students interpret the data. They ask, “What does the data tell us?” and “Does it answer our question?”

- More people like dogs than cats and hamsters.
- Only 3 people liked hamsters as pets.
- 8 people liked cats.
- 4 more people liked dogs than cats.
- The number of people who liked hamsters was 3 less than the number of people who liked cats.
- 23 people answered the question.

In second grade, students represent and interpret data as they measure the lengths of several objects in order to generate measurement data. Students then create a line plot by drawing a number line and then placing an X above the value on the line. Students must be sure to be consistent and line up the Xs so that their line plot resembles a bar graph.

For example, students measure the lengths of their shoes to the nearest whole inch. The class results are on the line plot below.

Number of Shoes Measured



Long Description: Two students, in this example, are marked with two x's vertically at four inches, five X's vertically at five inches, three X's at six, and four at seven.

Students also begin to work with categorical data as they organize, represent, and interpret the data. They should draw both pictographs and bar graphs. At this level, pictograph symbols should represent one unit. All pictographs should include a title, categories, category label, key, and data. Bar graphs should be both horizontal and vertical, and be sure to emphasize that all bar graphs require a title, scale, scale label, and category label and data.

In third grade, students read and solve problems using scaled graphs before they draw one.

Representing and interpreting data is a common cluster throughout grades 1-5. In kindergarten, students identify and describe measurable attributes of objects, directly compare two objects, and identify the similarities and differences between objects. In first grade, students create graphs and tally charts using data that is relevant in their lives, and second grade students make line plots, draw picture graphs, and bar graphs to represent a data set. Third grade students build on the work they did in second grade and continue to draw picture graphs and bar graphs.

Please see the [Wisconsin Model Early Learning Standards](#) for specific information detailing how preschool students can participate activities that help them develop data analysis skills and the strategies teachers can use to help foster the development of those skills. **Standard B.EL. 6 Collects, describes, and records information using all senses** aligns with data analysis.

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5.7: Standards

Course Competency 5. Examine strategies that teach early math skills.

CRITERIA 5.7. examine the National Council of Teachers of Mathematics standards.



Standards describe what students are expected to learn in each grade and each subject. Each state Department of Education creates standards for schools within the state. These standards become the basis for the way teachers are trained, what they teach and what is on state standardized tests that students take. Without standards, districts and schools don't have goals. By matching what is taught in the classroom to the standards in each subject area, students will know what teachers should be teaching, what students should be learning, and what they will be tested on (GreatSchools Staff, 2012).

As an early childhood teacher in Wisconsin, you need to be familiar with three sets of standards: the Wisconsin Model Early Learning Standards, the Wisconsin Standards for Mathematics, and the National Council of Teachers of Mathematics Standards.



Wisconsin Model Early Learning Standards

The [Wisconsin Model Early Learning Standards](#) were first completed in 2003, with revisions in 2008, 2011, and 2013, and an update to the 2013 standards was completed in 2017. See the [Wisconsin Early Childhood Collaborating Partners](#) website to learn more about the purpose and the guiding principles of the standards.

Research shows that young children can do mathematics and solve problems. Long before entering school, young children explore and use mathematics and do it naturally. Children at play begin to learn essential math skills such as counting, equality, addition, subtraction, estimation, planning, patterns, classification and measurement. They compare, notice similarities and differences, and group toys and materials. This ability to organize information into categories, quantify data and solve problems helps children learn about time, space and numbers. Over time, they develop the vocabulary and skills to:

- Measure,
- Describe patterns,
- Express order and position, and
- Describe relationships between objects in the environment.

Mathematics helps children make sense of the physical and social worlds around them and they naturally incorporate math as they make comments such as:

- “He has more than I do!”
- “That won’t fit in there, it’s too big.”

- “I can’t move it, it’s too heavy.”

Organization of the Wisconsin Model Early Learning Standards

The Wisconsin Model Early Learning Standards for Mathematical Thinking have been divided into six broad areas or strands.

- **Number Sense** -- B. EL. 1 Demonstrates an understanding of numbers and counting.
- **Number and Operations** -- B. EL. 2 Understands number operations and relationships.
- **Geometry** -- B. EL. 3 Explores, recognizes, and describes, shapes and spatial relationships. Algebra and Functions (Classification and Patterning)
- **Algebra** -- B. EL. 4 Uses the attributes of objects for comparison and patterning.
- **Measurement** -- B. EL. 5 Understands the concept of measurement.
- **Data Representation** -- B. EL. 6 Collects, describes, and records information using all senses

Wisconsin Standards for Mathematics

These Standards define what K-12 students should understand and be able to do in mathematics. Asking a student to understand something means asking a teacher to assess whether the student has understood it.

Organization of the Wisconsin Standards for Mathematics

There are two sets of standards; **Content Standards** and the **Standards for Mathematical Practice**.

The standards for mathematical content are focused on number and quantity, algebra, functions, geometry, modeling, and statistics and probability. For kindergarten through grade 8, the content standards are organized by grade levels. The 9-12 standards do not use grade bands, but instead have broad conceptual categories. All content standards are organized by Domain, Cluster, and then Standards.

Domains are larger groups of related standards. The Domain is the big idea.

Clusters are groups of related standards. At the beginning of each cluster, the bold label is referred to as the Cluster Heading

Standards define what students should understand and be able to do.



Standards for Mathematical Practice

The Standards for Mathematical Practice (SMPs) describe varieties of expertise that mathematics teachers at all levels should seek to develop in their students. The SMPs represent the habits of mind that represent thinking and understanding.

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Please see the [Wisconsin Standards for Mathematics](#) for more information on the Content Standards and the Standards for Mathematical Practices.

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National Council of Teachers of Mathematics (NCTM)

To learn more about the NCTM guiding principles and the **content** and **process standards** see [NCTM](#) website.

Supporting Mathematical Reasoning

The Wisconsin Model Early Learning Standards do not have math process or reasoning standards.

Mathematical reasoning is a key process in learning and developing mathematical knowledge in all areas of mathematics, including number and operations, classification, patterning, measurement, and geometry. It involves the ability to think and reason logically, to apply mathematical knowledge in different problem-solving situations, and to come up with different solutions. Mathematical reasoning is natural to most young children as they explore the environment and make sense of the world around them. View the California Learning Standards for mathematical reasoning below.

At around 48 months of age	At around 60 months of age
1.0 Children use mathematical thinking to solve problems that arise in their everyday environment.	1.0 Children expand the use of mathematical thinking to solve problems that arise in their everyday environment.
1.1 Begin to apply simple mathematical strategies to solve problems in their environment.	1.1 Identify and apply a variety of mathematical strategies to solve problems in their environment.



Figure 5.4: This boy uses mathematical reasoning when he constructs his train tracks.^[17]

Teachers can support children's development of the mathematical reasoning foundations with the following:

- Identify and create opportunities for mathematical reasoning through both spontaneous interactions and planned experiences
- Pose meaningful questions that promote investigation and inquiry and challenge children to think through a problem and come up with a solution
- Support preschool children in reasoning mathematically by providing clues, encouragement, and modeling, as needed^[18]

Guiding Principles for Supporting Mathematics

The following principles will guide teachers' classroom practices in establishing a high-quality, challenging, and sensitive early mathematics preschool program. These principles are partially based on the ten recommendations in *Early Childhood Mathematics: Promoting Good Beginnings* set forth by the National Association for the Education of Young Children and NCTM in 2002.

- Build on preschool children's natural interest in mathematics and their intuitive and informal mathematical knowledge
- Encourage inquiry and exploration to foster problem-solving and mathematical reasoning
- Use everyday activities as natural vehicles for developing preschool children's mathematical knowledge
- Introduce mathematical concepts through intentionally planned experiences (in addition to what they spontaneously engage in)

- Provide a mathematically rich environment
- Provide an environment rich in language, and introduce preschool children to the language of mathematics
- Support English learners in developing mathematical knowledge as they concurrently acquire English
- Observe children to discover opportunities to clarify, extend, and reinforce their existing mathematical concepts and to help them discover new mathematical concepts
- Provide an environment in which all children can learn mathematics, set appropriately high expectations for all children, and support individual growth
- Establish a partnership with parents and other caregivers in supporting children's learning of mathematics[1]

Engaging Families

Teachers can use the following strategies to help families to develop their children's mathematical understanding:

- Communicate to families
 - the broader aspects of developing number sense; for example, using counting in real-life situations, comparing numbers and discussing which is more or less, making estimations (e.g., How many grapes are in this bowl?), and solving simple addition and subtraction problems.
 - what classification and patterning are about and how they contribute to children's understanding of mathematics.
 - the importance of early measuring experiences and types of measurement experiences they can do with children.
 - that mathematical reasoning is being able to think mathematically and explore different ways of solving problems
- Remind parents that daily use of numbers (which are everywhere!) can become learning experiences for children.
- Provide number-related games and books that children can take home or that families can make or purchase.
- Encourage parents to
 - involve children in everyday measurement experiences
 - refer to shapes in the environment when talking with children
 - use spatial words in everyday interactions with children
 - recognize math in everyday events and interactions and turn them into learning experiences[1]



Figure 5.6: Cooking and baking are excellent opportunities to explore math with children.[2]

Things to Remember

Young children have a natural interest, curiosity, and competence to explore and construct mathematical concepts. Mathematics is a way of thinking and organizing the world around us. It is a natural part of day-to-day activities and events. Mathematics in preschool is learned through children's play and exploration as in the blocks area or the sandbox, through everyday routines such as setting the table and cleaning up, and through participation in teacher-initiated activities. Some teacher-initiated activities are designed with a focus on math, and others may focus on art, movement, literacy, or science but present opportunities for math learning.

When teachers recognize the potential for exposure to math in different situations, they can turn everyday occurrences into exciting and effective mathematics-learning experiences. Children are excited to explore the size or volume of objects, to discover and create patterns, to manipulate and build with shapes, to sort and classify objects, and to try to figure out "how many." Teachers get to experience with children the day-to-day excitement of learning and discovering math. This process is joyful for the children and for the teacher, who guides and challenges them in building mathematical concepts, skills, and language [1]

✓ Pause to Reflect

Many adults (including parents and teachers) shy away from math because they “aren’t good at it.” How do you feel about math? How comfortable are you “teaching” math? Has the way this chapter presented math affected that at all? If so, how?

References

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CHAPTER OVERVIEW

6: Early Technology Experiences

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6.1: Technology in Early Childhood

Course Competency 6. Examine strategies that teach technology skills

6.1. define technology in ECE.

Considerations for Technology Use in Early Childhood

The rapid development of technological devices such as computers, smart-phones, tablets, and gaming systems has dramatically changed people's daily lives at home and at work. New technologies and electronic media provide tools for communication and social networking, for searching and documenting information, and for learning and entertainment. Young children are growing up surrounded by technology and electronic media. At least two-thirds of homes with children (birth to age six) have computers and Internet access (Gutnick et al. 2010; Roberts and Foehr 2008). Moreover, according to a national survey by Common Sense Media in 2011, 52 percent of young children (birth to age eight) have access to smartphones or tablets (Rideout 2011). Young children are active media users (Roberts and Foehr 2008). They acclimate with ease to digital devices and show confidence in using software (Clements and Sarama 2008). With the prevalence of technology and electronic media in their environment, young children are spending an increasing number of hours in front of screen technologies, particularly television, but also computers and other devices, with an average of 2.2 hours per day of screen time for children between the ages of two and five (Roberts and Foehr 2008).

Children from low-income families, families with less education, and black, Hispanic, and rural families are less likely to have access to the newest technologies and to broadband connections to the Internet (U.S. Department of Commerce 2011). Inequality in access to technology has narrowed over the years, but the “digital divide” still exists (Roberts and Foehr 2008).

The pervasiveness of electronic media in the lives of many young children makes educators, parents, and advocates question the value of technology in children's development. Some electronic media such as certain television programs, videos, and DVDs are non-interactive and involve passive viewing. Other forms of electronic media such as software programs, applications, the Internet, e-books, and certain television programs facilitate active and creative use by young children. These latter forms are referred to as interactive media (NAEYC and FRC 2012). There is limited research on the impact of newer technology, such as computer software, handheld devices, interactive applications for mobile devices, and wireless technology, on children's development. Most of the research on the impact of media on young children has focused on television and video. Studies of infants and toddlers suggest that videos have no language benefits for infant and toddlers.

Young children learn much better from real-life experiences than from watching videos. Moreover, excessive exposure to electronic media may have a negative effect on attention development, particularly for children younger than two (Kirkorian, Wartella, and Anderson 2008). Research indicates that the impact of electronic media on older children depends on the age of children, the context in which they use media, the content of the media, and the amount of time they spend with screens (Kirkorian, Wartella, and Anderson 2008; Campaign for Commercial-Free Childhood, Alliance for Childhood, and Teachers Resisting Unhealthy Children's Entertainment 2012).

By age three, children can benefit from well-designed, age-appropriate electronic media, especially when a caring adult views the program with the child and is actively involved in the child's experience. Research emphasizes the importance of developmentally appropriate *content* being offered to children, whether on television or other interactive media software. Educational television programs that were designed around a curriculum with a specific goal to communicate academic or social skills were linked to various cognitive and academic enhancements, with potentially long-lasting effects (Fisch 2004). For example, research demonstrates a positive association between early exposure to *Sesame Street* television episodes and school readiness (Zill 2001). However, television and videos with entertainment content, particularly violent content, were associated with poor cognitive development and lower academic achievement (Kirkorian, Wartella, and Anderson 2008).

Studies of preschool children's computer play demonstrated that young children can use computers and software to support their learning. Children can understand, think about, and learn from their computer activity (Clements and Sarama 2008). Research has shown that in children's computer play with interactive media software there is a period of discovery, which is then followed by involvement, self-confidence, and creativity (Bergen 2008). Computer-play software can offer children various possibilities,

including *practice* (self-directed repetition to achieve mastery), *pretense* (symbolic play in a “pretend to be” world), and *games* (challenge and competition, either with a peer, with oneself, or with an imaginary opponent) (Kafai 2006).

There is limited research on how educational computer software may enhance preschool children’s academic-readiness skills. Some research suggests that software with an educational curriculum may have a positive influence on learning (Din and Calao 2001). Overall, studies indicate that, when used appropriately, technology and media can enhance children’s cognitive and social abilities (Kirkorian, Wartella, and Anderson 2008). Even so, additional research is needed to confirm the positive outcome of technology on children’s language and vocabulary, understanding of math concepts, self-regulation, and social-skills development (NAEYC and FRC 2012).[1]

Technology and Interactive Media in the Preschool Environment

Technology has many uses in early childhood settings. On any given day, teachers may use technology to support children’s learning, to record and document children’s development, to expand their own knowledge in different areas, to maintain ongoing communication with families, and to link homes with school. The focus in this chapter is on the use of technology and interactive media in pre school settings for the purpose of supporting and enhancing children’s learning.

A growing number of early childhood educators use technology and interactive media in their programs as tools to support children’s learning and development (Wartella et al. 2010). In a recent survey by the Fred Rogers Center (Wartella et al. 2010) about technology in the lives of teachers and classrooms, nearly 60 percent of early childhood teachers reported having a computer, and 45 percent have computers with Internet access in their classrooms. More than half of the early childhood teachers indicated that children should be introduced to technology in the classroom between ages three and four, and about one-third of the teachers reported using computers with children on a daily basis (Wartella et al. 2010). With the increasing interest and use of technology in preschool settings, early childhood educators need guidance on how to use technology and interactive media wisely and effectively. Several important questions come to mind:

- Which technology and media tools are effective tools for learning?
- In which domains of development can the use of technology be most effective?
- How do early childhood educators appropriately integrate technology and media into preschool settings?
- How can technology be used to support children’s learning?



Figure 6.1: How programs will include technology in their curriculum is something that should be thoughtfully considered.[2]

A joint position statement issued in 2012 by the National Association for Education of Young Children (NAEYC) and the Fred Rogers Center (FRC) offers guidance. Based on research, the statement addresses both the opportunities and the challenges related to using technology and interactive media in early childhood programs. The following section presents key messages from the NAEYC/FRC position statement on technology. A set of strategies consistent with the approach articulated in the position statement is provided to guide administrators and teachers in integrating technology and interactive media into preschool programs. [3]

The Benefits and the Challenges of Using Technology and Interactive Media

Technology and interactive media have the potential to make many contributions to early childhood education. Technology can provide children with additional ways to explore, create, communicate, problem-solve, investigate, and learn. Computer technology, for example, offers young children a range of learning opportunities—from solving math problems to listening to interactive stories, taking a photo, recording a story, creating a digital book, making music, and engaging in other age-appropriate learning activities (Blagojevic et al. 2010). Many educational applications for young children are designed to help children develop skills and knowledge in specific domains, particularly in areas such as language, literacy, and mathematics (Buckleitner 2011).

Such programs can provide individualized learning opportunities for children. In mathematics, computer programs present children with tasks, give feedback, and help young children develop concepts and skills in areas such as counting, number relationships and operations, sorting and patterning, measurement, and geometry (Clements and Sarama 2008; McCarthy, Li, and Tiu 2012). In language and literacy, computer software can enhance vocabulary learning (Segers and Vermeer 2008) and support learning of listening, speaking, writing, and reading skills (Guernsey et al. 2012). Dual language learners can also use computers to enhance their home language and acquire English (Blagojevic et al. 2010; Nemeth 2009).

The use of technology can also enrich the science curriculum. Cameras and recording devices provide valuable educational experiences by allowing children to take photos and videos to document objects and events and track changes in objects and materials. Digital microscopes allow children to save images of objects they explore and to share and discuss such images with their peers. Robotics with manipulative motors and gears engage young children in designing their own robotic creations, providing them with opportunities both to be creative engineers and to explore abstract mathematical and science concepts in concrete ways (Bers 2008).

The use of technology in preschool settings also creates opportunities for equitable access to technology tools and interactive media experiences for children from different economic backgrounds, including children in families with few resources and little or no access to the latest technologies (NAEYC and FRC 2012). Furthermore, technology has many potential benefits in supporting inclusive practices for children with disabilities or other special needs (Mulligan 2003).

A variety of assistive and adaptive technologies (e.g., electronic communication boards, switch-activated toys, recordable devices) enhance children's participation and learning with peers. For example, a child who enjoys playing with bubbles can operate an electronic bubble-blower for other children to chase (Mistrett 2004). Another child can let a peer know which game she wants to play by indicating it on the electronic tablet that has photos taken by her teacher. By using assistive technology, early childhood educators can help children with disabilities or other special needs become more independent. Children with special needs can use technologies to support their ability to communicate and interact with others, move throughout the environment, manipulate objects, and participate in daily routines and educational activities.



Figure 6.2: Technology can help children with disabilities participate in the environment and communicate.[4]

Overall, effective uses of technology and interactive media can enhance and augment children's learning in different domains, extending children's access to new content. However, technology is effective only when used appropriately. Although the use of technology and interactive media provides programs with opportunities to enhance quality and optimize young children's development, early childhood educators should understand the limits of technology and be aware of the challenges of using technology and interactive media in the preschool environment. As stated in the NAEYC/FRC position statement, "Technology and interactive media are tools that can promote effective learning and development when they are used intentionally by early childhood educators, within the framework of developmentally appropriate practice, to support learning goals established for individual children" (NAEYC and FRC 2012, 5).

Technology and interactive media should only supplement, not replace, existing play-based materials and active play, engagement with other children, and face-to-face interactions with adults. Several professional and public health organizations have raised concerns about whether young children should have access to technology and screen media in early childhood programs (e.g., Campaign for a Commercial-Free Childhood, Alliance for Childhood, and Teachers Resisting Unhealthy Children's Entertainment 2012). The American Academy of Pediatrics recommends avoiding any media other than video-chatting until 18 months, limiting 2 to 5-year-olds to one hour per day of high quality programming, and for ages 6 and older, placing consistent limits on time and types of media. These recommendations are focused on preventing media use from displacing physical activity, hands on exploration, and face-to-face social interaction in the real world, which are critical to learning.

This chapter follows the recommendations of the NAEYC and the Fred Rogers Center (2012) and is aligned with the public health community in discouraging the use of screen media for children under the age of 24 months in early childhood programs. Such guidance for educators working with infants and toddlers may change in the future as more research on very young children's active use of interactive media and its effect on children's learning and development continues to emerge (e.g., Zack et al. 2013).

Monitoring the content of interactive media is as important as setting limits on the time young children spend with technology. Although there are valuable software, websites, and other forms of interactive media for young children, some have limited educational value or may include content that is not safe or appropriate for children. The challenge for early childhood educators is "to make informed choices that maximize learning opportunities for children while managing screen time and mediating the potential for misuse and overuse of screen media" (NAEYC and FRC 2012, 3). Educators should have the knowledge, skills, and experience necessary to select and use technology tools and interactive media that suit the age and developmental level of children and can be integrated effectively in the environment (NAEYC and FRC 2012).

The following guidelines identify key considerations for programs and teachers selecting, evaluating, integrating, and using technology in preschool programs.[5]

Selecting Technology and Interactive Media to Enhance Children's Learning

The rapid development of technology platforms, including computers, laptops, multitouch tablets, and other handheld devices, and the growing selection of available educational applications, Web sites, and software present educators with many choices for integrating technology into the preschool environment. However, technology and media-based products may vary widely in quality. Intentionality is important. Thoughtful, advance planning is essential for a responsible investment in technology in early childhood settings. Early childhood educators should apply their expertise and knowledge of child development in selecting appropriate technology and media for the classroom in the same way that they select any other instructional materials (NAEYC and FRC 2012). Educators should take the time to evaluate and select technology, to observe children's use of the materials, and to make appropriate adoptions based on their observations. The Fred Rogers Center (2012) proposed a framework for quality in digital media (FRC 2012), recommending that educators take into account the *child*, the *content*, and the *context* in the selection of digital media for young children.

- **Consider children's developmental level, interests, abilities, and cultural and linguistic backgrounds.** Teachers must be intentional in selecting the technology and interactive media they offer children in their classroom. In selecting appropriate technology and interactive media, educators make decisions that are informed by developmentally appropriate teaching practices, which means that early childhood educators consider the age, developmental level, needs, interests, linguistic backgrounds, and abilities of individual children in the group (NAEYC and FRC 2012).
- **Ensure equitable access to technology and interactive media experiences.** In selecting technology and interactive media, educators provide opportunities for all children to participate and have access to these learning tools. Educators should consider the cultural and linguistic backgrounds of the children in their classrooms. Technology resources can provide access to children's home language and culture, especially when there are no other ways to obtain such information (NAEYC and FRC 2012). For example, children can listen to electronic books in their home language, record songs and stories, and create digital stories in their home language and English (Blagojevic et al. 2010). Educators can collaborate with family members and colleagues who speak children's home language to gain access to appropriate interactive media in children's home language.

Materials and equipment selected for children with disabilities or other special needs should be evaluated. Adaptive and assistive technologies are available to support individual children in their classrooms. Programs should consider the level of technology necessary and the child's individual needs to ensure that the technology is best suited to the child's unique disabilities and to the demands of the environment (Mulligan 2003). Not all assistive devices are necessarily "high tech" or custom designed for a particular child. In fact, the Individuals with Disabilities Education Act defines an assistive technology device as any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability (Mistrett 2004).

- **Identify the underlying objectives of the technology.** Most electronic media targeted at preschoolers are intended to entertain rather than to teach. Technology in the preschool environment should be used only for educational activities. In evaluating any software programs, applications, or other forms of interactive media, educators should be able to identify the overall goals or purpose of the product: Is it to educate or to entertain? Is it interactive? Is it to develop particular skills, to introduce children to

new information, or maybe a combination of these (FRC 2012; Campaign for Commercial-Free Childhood, Alliance for Childhood, and Teachers Resisting Unhealthy Children's Entertainment 2012)? Understanding the intent of a digital program and the learning goals for different children in the program should guide educators' intentional decisions in selecting materials of interactive media (FRC 2012).

- **Evaluate the quality of the content.** First and foremost, educators should evaluate the quality of the content to ensure that the use of such materials would not harm young children's overall development or well-being in any way (NAEYC and FRC 2012; FRC 2012). Interactive media products can be used as tools to fulfill the needs of individual children and to expand children's access to new content in areas of interest to them. In the selection process, program administrators and teachers should have information and resources regarding the nature of these tools and the implications for use with children. Program administrators and teachers should also have hands-on opportunities to explore and directly experience the technology that is being considered for use with children. Educators can apply their expertise and knowledge of child development to ensure that digital materials are developmentally and culturally appropriate for the children in the group. They should examine the educational content, format, and features and carefully consider any implicit messages communicated during the use of the software/application. Some undesirable messages (e.g., stereotypes, negative images or actions) may be biased and fail to promote social and emotional understanding in the early years (Tsantis, Bewick, and Thouvenelle 2003).
- **Select technology and interactive media that support children's creativity, exploration, and problem solving.** In selecting activities with technology and interactive media, early educators should ask themselves: *Does it encourage children to explore, to think, to experiment and predict, to be creative, and to problem solve? Does it offer a range of experiences and a high level of interactivity? Is it open-ended or focused on skills?* Experiences with technology and other media that engage children in redundant practice and rote learning or involve passive use by children are not desirable. Effective technology and media empower children by giving them control, offering challenges through "leveled" experiences, and providing them with feedback and adaptive scaffolds (Clements and Sarama 2008).
- **Use the best available evidence in the selection process.** More research is needed to understand what young children are able to do with different digital devices and to assess the short- and long-term effects of new technologies on children's learning. Educators are encouraged to make their decisions about the quality of interactive media products based on the best available evidence for any given product (FRC 2012).^[6]

Integrating and Using Technology in the Preschool Environment

Once the desired software or appropriate technology devices for the program are selected, educators should apply their expertise and knowledge of child development to make thoughtful decisions on how to introduce and integrate the selected forms of technology into the learning environment. The teacher's role is critical in ensuring that technology is implemented in ways that serve the teaching goals and support children's learning appropriately and effectively.

- **Technology and interactive media are used within the framework of developmentally appropriate practice.** Developmentally appropriate practice encourages hands-on exploration; empowers children to reflect, question, and create; and honors the value of relationships between children and the adults in their lives (NAEYC 2009). Professional knowledge of developmentally appropriate practice informs and guides decision making about how to introduce and integrate any form of technology and interactive media into early childhood programs. Technology and media should not replace preschool activities such as real-life exploration, physical activity, social interactions, outdoor and indoor play, and arts. Instead, they should be used as additional tools to encourage children's problem solving, exploration, and creativity. They can also support children's relationships with both adults and their peers and foster children's autonomy (NAEYC and FRC 2012; Donohue and Schomburg 2012; Nemeth and Simon 2012), particularly for some children with disabilities (Mistrett 2004).
- **Technology and interactive media are integrated into the environment, curriculum, and daily routines** (NAEYC and FRC 2012). True integration of technology and media into the preschool environment involves the use of different technology resources throughout the classroom. No period is set aside in the daily schedule for "computer time," when technology and media are used as isolated activities. Technology and interactive media are woven into the fabric of the day and are used as tools for learning, rather than as the focus or the goal of a learning activity. Technology is one of many ways to support curriculum goals and needs, and the program offers a balance of activities to support children's development in all domains of learning. In using a particular application or software, teachers should consider how it supports objectives for individual children in the

group, how it fits into the classroom's current curriculum project or theme of study, and how it extends other activities in ways not possible otherwise (Nemeth and Simon 2012).

- **Time spent with technology and media is limited.** Setting limits on the time young children spend with technology and interactive media is important. As previously indicated, the public health community discourages the use of passive screen media for children under two years of age and recommends limited screen time daily for children older than two (American Academy of Pediatrics 2011). Some of the public health concern is that the overuse of media takes time away from other activities that involve physical exercise. Sedentary activities are potentially a risk factor for childhood obesity (Wartella and Heintz 2007). The position statement by the NAEYC/FRC points to the following recommendation in the *Early Childhood Obesity Prevention Policies*: “child care [and preschool] settings limit screen time to fewer than 30 minutes per day for children in half day programs or less than one hour per day for those in full day programs (Birch, Parker, and Burns 2011).” Teachers play a critical role in establishing clear boundaries on the use of technology and screen time in the preschool setting. They are also encouraged to share information with families on how to promote children's healthy use of technology at home (Campaign for a Commercial-Free Childhood, Alliance for Childhood, and Teachers Resisting Unhealthy Children's Entertainment 2012).
- **The use of technology and interactive media facilitates social interactions and relationship building.** Effective use of technology and interactive media in the classroom environment allows joint engagement, specifically viewing and participation by both children and adults and children and their peers (NAEYC and FRC 2012). Studies on the social dimension of preschool children's computer play found that preschoolers observe each other while playing, comment on others' actions, share and help with software-related problems, and have conflicts over turn-taking (Heft and Swaminathan 2002). The computer and other digital devices should be located in spaces that allow for joint engagement of a group of children. Some children may select technology such as the computer because it is familiar or even as a way of avoiding interaction. Careful observation is needed to monitor the use of technology and determine individual appropriate use. Effective use of technology and interactive media can promote communication and collaboration among children (Wright 1994). It often provides the context for information sharing, language development, and collaborative decision making (Tsantis, Bewick, and Thouvenelle 2003). Tech-savvy children may also become computer mentors for their peers (Blagojevic et al. 2010).



Figure 6.3: This teacher is monitoring children using the computer together.[7]

- **Teachers provide support while children use technology and interactive media.** As with any learning activities, teachers play an important role in facilitating children's involvement with technology and media. The teachers introduce children to the computer or another device (e.g., digital camera, printer, touch-screen), and explain how it works. They observe what individual children do and learn about children's ability to use technology. Children vary in the ability to use technology and interactive media. Teachers also give children time to freely explore new technology tools, model appropriate use of technology, and help children become familiar with any new software activity. They establish rules and routines with children to guide appropriate handling and use of computer and other technological devices (Blagojevic et al. 2010; Campaign for a Commercial-Free Childhood, Alliance for Childhood, and Teachers Resisting Unhealthy Children's Entertainment 2012). During technology-related activities, teachers carefully observe and document what children do and assess children's learning. Teachers identify problems or opportunities for teachable moments, extending the media experience to other learning opportunities, and facilitating the experience through language-rich interactions. In addition, teachers determine when the child is ready to progress to the next level of knowledge or skill development (FRC 2012). They consider children's varying abilities to control and operate technology and media and support children's “technology-handling” skills, as needed. Teachers make appropriate adaptations, based on their observations, to promote positive outcomes for individual children.[8]

References

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6.2: Technology as a Tool in Early Childhood Education

Course Competency 6. Examine strategies that teach technology skills

6.2. incorporate using tools.

What are Tools?

Technology-related learning activities can range from investigating how machines like gears, wheels and pulleys work to mastering simple coding. Developmentally appropriate technology activities during the early years are hands-on, with minimal use of screens (e.g., computer, tablet, television, etc.). The National Association for the Education of Young Children (NAEYC) position paper titled “Technology and Interactive Media as Tools in Early Childhood Programs Serving Children from Birth through Age 8” concludes “Technology and interactive media should not replace other beneficial education activities such as creative play, outdoor experiences, and social interactions with peers and adults in early childhood settings. Educators should provide a balance of activities in program for young children, and technology and media should be recognized as tools that are valuable when used intentionally with children to extend and support active, hands-on, creative, and authentic engagement with those around them and with their world.” (pg. 11)



Pause and Reflect

Tools can be electronic devices, but they don't have to be. A tool is anything that helps you get a job done more effectively or more efficiently. Some tools may work better than others. Think about the tools you are using to read this text. If you are using a computer to read the text, you are using different tools than you would be using if you are reading a paper copy of the text. One tool you would need to read a paper copy of the text would be a light source. This could be a candle, a flashlight, an electric overhead lamp or even the sun. It is difficult to read a text in the dark, so a light source is a very useful tool. Can you think of any other tools you may have used today?

Think about the types of tools children might use in the preschool classroom.

When children are painting, what are all the tools they need to use? What about during a cooking activity or a math activity?

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6.3: Coding



What is Coding?

Coding is step-by-step instructions that a computer understands for programs to work. Our cars, tablets, and cell phones all use coding to work properly. However, children don't have to start out making coding instructions for computers. There are many activities children can participate in called "pre-coding" activities that don't involve using a computer.

Coding Stories and Games for Preschool

Pre-coding activities for preschoolers involve directional language, ordinal numbers, and one-to-one correspondence. Directional language involves understanding words such as up and down, backward and forward, left and right. Children must also know how to count using ordinal numbers, such as first, second, and third. Children must also understand one-to-one correspondence meaning they only count each item once. All children will be at different places in their understanding of these concepts. Some children will have mastered these skills while others are still

learning them. That is ok because pre-coding activities help to develop these skills.

See [Creating Coding Stories and Games](#) to learn more about the benefits of coding with young children and for ideas for pre-coding activities.

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6.4: HOT Skills

What are HOT Skills?

HOT stands for **HIGHER ORDER THINKING**.

HOT skills include:

- Analyzing
- Predicting
- Planning
- Patterning
- Sequencing
- Sorting
- Organizing
- Remembering
- Rulemaking
- Breaking down tasks
- Evaluating

(For More Information SEE: [The T in STEM: Creating Play-Based Experiences that Support Children's Learning of Coding and Higher Order Thinking](#))



How can early childhood educators begin to expose young children to technology and strengthen HOT skills without using technology?

It is important for children to have many opportunities to work on the development of HOT Skills in hands-on and play-based ways before they are asked to use Hot Skills with technology.

The **NAEYC** suggests 5 activities that don't rely on the use of technology.

1. **Block Play:** Provide a variety of blocks (color, shape, size) for children to create patterns and sequences. Older children can create more complex patterns that must be analyzed to “decode” a secret message.
2. **Reading:** Read developmentally appropriate books that provide opportunities for predicting what might happen next in the story and remembering details.
3. **Storytelling:** Have children work together to write a story that has a beginning, a middle, and an end. Have the children create pictures that tell their story and have other children put the pictures in the right sequence.
4. **Art:** Have the children create a system of directional arrows, stop, and go signs (e.g., a pink arrow means “go right” while a green arrow means “go left”).
5. **Game Design:** Have children draw a map on grid paper for a “robot” (one child) to follow using their directional arrows and symbols. The children will need to count each square so they can tell the “robot” how many “steps” (squares on the grid) to take in each direction; in other words, a “code.”



Figure 6.4: Exploring technology with robots (Photo by [Robo Wunderkind](#) on [Unsplash](#))

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6.5: MakerSpaces



What is a Makerspace?

Makerspaces are plain and simple, an area where children and adults can gather to tinker and make things. The spaces can be NO Tech, Low Tech or High Tech. Since space is a premium in most preschool classrooms, it may make sense to have the Makerspace be next to or near the art area as they will share some supplies.

According to the [Preschool STEAM](#) website, Makerspaces are places where children can "can explore, tinker, and create using a variety of materials and tools." Makerspaces allow for collaboration, help children develop creativity, and provide a place to engage in hands-on learning and experimentation. See the [Preschool STEAM](#) website for more information.

Children's Role During Tinkering

The National Association for the Education of Young Children (NAEYC) breaks the role of the children during Tinkering into 3 steps:

1. Tinkering -- "Using the stuff"
2. Making -- "Using the stuff to make stuff. Sometimes it does something and other times it is just cool."
3. Engineering -- "Using stuff to do stuff that makes stuff."

Role of the Teacher

The teacher's role is of course to supply the area with a variety of materials. In addition to providing materials, teachers:

- Encourage thinking and problem-solving by asking open-ended questions.
- Provide the children plenty of time to design, build, and test their products.
- Help children to fix mistakes by encouraging the children to make new discoveries on their own and use trial and error along the way. (Do not fix the mistakes for the children.)
- Teach children how to safely use the "real tools" and to monitor them when in use.
- Establish rules for how to use the tools and to help the children to see and manage risks. Tools the children might use may include: child safety goggles, low-temperature glue guns, measuring tapes, rulers, scissors, funnels, child-size hammers, pliers, screwdrivers, etc.



Makerspace Materials

You will want to include materials that allow the children to do various things such as building, connecting, sculpting, mixing, write, and decorate. The list or suggested materials below is from [Makerspaces in Early Childhood Settings](#) from The Learning Child Blog.

- **For building:** popsicle sticks, straws, paper plates and cups, corks, wood scraps, pipe cleaners
- **For Connecting:** A variety of tapes such as masking, duct, and cellophane, staplers, glue sticks, beads, string, clothespins, rubber bands, paperclips and binder clips
- **Sculpting:** modeling clay, play dough, and tools such as rolling pins, plastic knives
- **Mixing tools:** plastic bowls, spoons, pitchers, and ingredients for science exploration such as corn starch, and vinegar
- **Fabrics and decoration:** pom-poms, feathers, buttons, fabric scraps, felt,
- **Writing materials:** markers, pencils, pens, crayons
- **Electronics and technology:** batteries (keep in a battery holder) flashlights, beginning circuitry kits (These items would be for the more advanced engineers)

Makerspace Location

A Makerspace shares many materials with an art center, so having them adjacent can help with organization and space. The materials in the Makerspace should be organized and easily accessible to the children. Clear containers work best so the children can see what is available for them to use. A wonderful resource for setting up a Makerspace is [Making and Tinkering with STEM](#) by Cate Heroman.

6.5: [MakerSpaces](#) is shared under a [CC BY](#) license and was authored, remixed, and/or curated by Vicki Tanck (Northeast Wisconsin Technical College).

6.6: Woodworking

The Benefits of Woodworking with Children

Woodworking with children may seem like a daunting task. As a teacher, you will have safety concerns and concerns about space, materials, and noise. However, woodworking is an activity that is well worth the concern as it provides development in every domain.

Woodworking provides development in:

Math

Scientific Investigation

Physical Coordination

Language

Creativity

Imagination

Self-esteem

Of course, children must be taught to use tools safely, but once they have mastered basic skills their creativity and problem-solving skills will soar.

View this wonderful resource from Community Playthings and Pete Moorhouse about [Woodwork in the Early Years](#).



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CHAPTER OVERVIEW

7: Early Engineering Experiences

7.1: Engineering

7.2: The Design Process

7.3: Types of Blocks and Stages of Block Play

7.4: Relationship to Geometry

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7.1: Engineering

Course Competency 7. Examine strategies that teach engineering skills.

7.1. define engineering in ECE

engineering

What is Engineering?

“While engineering practices—one aspect of STEM learning—are similar to (scientific) inquiry processes, there are some significant differences. Scientific inquiry involves the formulation of a question that can be answered through investigation, while engineering design involves the formulation of a problem that can be solved through design.” (Growing in STEM. The Design Process: Engineering Practices in Preschool)

In the early learning environment, engineering is about how things are built and why. These questions are best explored through play.



✓ Example: Water Conservation

“Three-year-olds Jessie and Michaela spend the morning exploring the effects of last night’s rainfall on the playground sandbox. After the sun dries the sand, they ask their teacher, Ms. Stefanie, for water to make the sand wet again. Ms. Stefanie frames this as a problem, asking them, “How can we transport water from the porch to the sandbox?” Ms. Stefanie helps a small group of interested preschoolers imagine solutions by providing photographs and nonfiction texts of water transportation systems—like pipes, aqueducts, and pulleys—to introduce them to ways others have addressed similar problems.

For several days, the children investigate potential solutions, realizing that the conservation of water should be one of their primary concerns. As they consider why preserving and reclaiming water matter, they sketch plans and discuss the merits and constraints of various models. Eventually, they agree to design a pipe system to move water. Ms. Stefanie provides copies of a blueprint of the playground, which the children use to draw their pipe plans. She asks them to think about the materials they need to create a prototype. The children list pipes, water, sand, buckets, tape, clay, twine, and sticks. Their enthusiasm for the project remains high, and Ms. Stefanie looks forward to guiding the children through a few cycles of the design process so they can improve their prototype and build a pipe system.”

(Growing in STEM. The Design Process: Engineering Practices in Preschool)

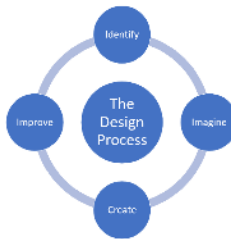
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7.2: The Design Process

Course Competency 7. **Examine strategies that teach engineering skills.**

CRITERIA 7.2. identify an engineering design process of ask, imagine, plan, create, and improve

The Design Process



Preschool-age children can begin to explore engineering concepts through a simple design process that includes four steps:

- **Identifying a Problem:** Identify a problem or need. Why is it important? How have others approached the problem?
- **Imagining and Planning:** Brainstorm solutions. Sketch possible plans. Choose one to build. List and gather needed materials.
- **Creating:** Refer to the plan and build a model or prototype. Share the model for feedback or test the prototype.
- **Improving:** Analyze the model or prototype with others. How could it be improved? Redesign based on feedback.

([Growing in STEM. The Design Process: Engineering Practices in Preschool](#))

3-Step Design Process

The design process described above has 4 steps. Some curriculums such as the EIE--Engineering is Elementary from the Science Museum of Boston use a simplified 3-step process. The steps in their process are:

1. Explore
2. Create
3. Improve

See [EIE](#) for more information.



Figure 7.1: Engineering in Toddlerhood Photo by [Ryan Fields](#) on [Unsplash](#))

7.2: The Design Process is shared under a [CC BY](#) license and was authored, remixed, and/or curated by Vicki Tanck (Northeast Wisconsin Technical College).

7.3: Types of Blocks and Stages of Block Play

Course Competency 7. Examine strategies that teach engineering skills.

CRITERIA 7.3. identify the stages of block play

The Value of BLOCKS

“Creative materials are, by definition, open-ended, divergent, abstract in design, freeform, and responsive to one’s actions on them – all characteristics that ensure that unit blocks are a most treasured type of creative play material” (Shipley, 2012, pg. 377)

Blocks have been recognized as valuable play materials since Friedrich Froebel (1782-1852) incorporated them into his kindergartens. Blocks provide opportunities for development in all domains for all ages of children. As a play material, they are particularly dynamic and responsive to the actions of the child.

Types of Blocks

Carolyn Pratt (1867-1954) is credited with creating the unit block system made up of solid wooden blocks. Unit blocks are standard proportions to promote mathematical concepts. A complete set of unit blocks (750 pieces) includes the following shapes:

Table 1: Unit Block System

Unit (14 cm x 7 cm x 3.5 cm)	Ramp
Square (½ unit)	Small column
Double unit	Large column
Quadruple unit	Half arch
Ellipse	Small buttress
Curve	Large buttress (flat edge)
Quarter circle	Large buttress (curved edge)
Gothic door	Arch
Large switch	Half circle
Small switch	Roof board
Switch or intersection	Pillar
Small triangle	Half pillar
Large triangle	

Other types of blocks include hollow wooden blocks, smaller tabletop building blocks, foam rubber blocks, and cloth blocks, blocks made of more lightweight cardboard, and Cuisenaire Rods.

Duplo, Mega Blocks, and Lego are often considered to be blocks, but they are distinct from traditional blocks because they have an interlocking mechanism to hold them together. The basic interlocking bricks of these products have some open-ended play value. However, the more complex sets of Lego that must be put together in a specific way to create a finished product are of limited value when the goal is to encourage creativity, representational thinking, and spatial skills. For these reasons, Lego should not be substituted for other types of blocks that encourage creative expression.

Nor should unit blocks be combined with other play materials. According to Shipley (2012), “The key to play with unit blocks is to encourage children to use the blocks alone and not combine them with other play materials or detailed accessories, such as dump trucks or Fisher-Price items. The abstract nature of the unit blocks contributes to children’s ability to hold on to their inner vision and assign meaning to an abstract structure.” (Shipley, 2012, pg. 377)

Stages of Block Play

Carrying: A toddler's first interactions with blocks usually involves just carrying them around or banging two blocks together.

Sometimes this is called Discovery or Exploring with the Senses.



Figure 7.2: Carrying stage of block play (Image by [Stacy Brunner](#) at [Flickr](#))

Stacking: During this stage, toddlers may attempt to stack three to four blocks to create a tower.



Figure 7.3: Stacking stage of block play (Image by [Freepik](#))

Bridging: Supporting a horizontal block on top of two vertical blocks is called “bridging.” Preschoolers are becoming more capable of the complex cognitive processes needed: planning which blocks to use, predicting what might happen, estimating how far apart to place the vertical blocks

Sometimes this is called Balancing and Bridging.

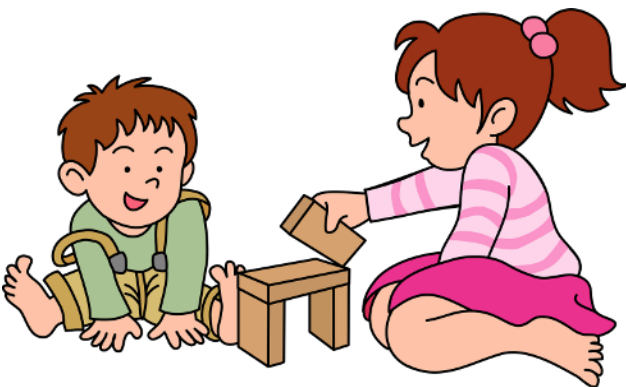


Figure 7.4: Bridging Stage of block play ([Creazilla](#))

Enclosures: Preschoolers will place blocks so they touch and create a space that is closed off on all sides. Typically, it is not until children are between 5 and 7 years of age that they use additional blocks inside of an enclosure to represent things; for example, furniture in a house or a car in a garage.



Figure 7.5: Enclosures stage of block play (Image by [Woodley Wonders](#) at [Flickr](#))

Patterns: During this stage, block play remains horizontal (that is, on the floor) for the most part. The concept of symmetry is explored by creating elaborate patterns with assorted block shapes.

This is also called Patterns and Symmetry.



Figure 7.6: Patterns stage of block play ([Play and Learn Everyday](#))

Representation 1: Creations become three-dimensional representations of real-world structures. Constructions are named and have a purpose.

This can also be called Early Representations or Early Representational--Symbolic Play.

Representation 2: Complex constructions such as houses and castles. Children begin to plan what they are going to build, often replicating familiar structures.

This can also be called Later Representational or Advanced Representational.



Figure 7.7: Representation stage of block play (Image found on [pxfuel](#))

Supplemental Readings

[Using Blocks to Develop 21st Century Skills](#)

[Building Bridges to Understanding in the Block Area](#)

[The Benefits of Block Play for Infants and Toddlers](#)

[Ten Things Children Learn From Block Play](#)

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7.3: Types of Blocks and Stages of Block Play is shared under a [CC BY-NC](#) license and was authored, remixed, and/or curated by LibreTexts.

7.4: Relationship to Geometry

Course Competency 7. Examine strategies that teach engineering skills.

CRITERIA 7.4. identify the relationship of block play to geometry



Block Play and Math

When children play with blocks they are practicing:

- Classification and seriation when they select blocks of differing sizes, shapes, and volumes
- Sorting similar and dissimilar shapes when tidying up
- Counting and measuring
- Estimating and predicting
- Spatial configurations

Educators can enhance exposure to mathematical concepts by asking the child questions about:

Size: How many blocks do we need to make the tower as tall as you? Will there be enough room in the garage you are building for all your cars to fit?

Shape: What is the shape of the house you are building? How many sides will it have? These two triangular blocks you put together are the same size as this square block. How come?

Orientation: I see you are trying to fit the blocks together. How do we turn the blocks so they will fit together? How can we connect pieces together to make it so your bridge doesn't fall?

Location: On what side will you build the door to your house

(Adapted from [Expand Mathematical Thinking During Block and Pretend Play](#))

Block Play and Science

Block play provides opportunities to explore a wide variety of scientific concepts and skills.

- Comparisons: Which block is smaller? Bigger? Taller? Longest?
- Gravity: What will happen if we take this block in the middle away?
- Balance: What will happen if we put this large block on top of this smaller block?
- Weight: Which block is the heaviest?
- Observation: Show me the curved blocks.
- Estimation: Which block do you think will fit here?

Adapted from [Questions in Block Play Can Support Scientific Learning](#))

Block Play and Prosocial Development

Block play is an excellent opportunity to help children learn and build prosocial skills, including:

- Sharing: Let's build together.
- Feelings: How did you feel when your tower fell over?
- Taking Turns: I'll put my block here and then you can put your block on top.
- Cooperating: Would you like to build the tower or hand me the blocks?
- Problem-solving: How can both of us build using the square blocks?

(Adapted from [Questions in Block Play Can Support Social Skill Development](#))

Block Play and Literacy

Block play is a literacy-rich learning opportunity.

- Imagination: Tell me about what you made with your blocks.
- Letters and print: Can you use the blocks to spell your name?
- Same and different: What is different about these two blocks? What is the same?
- Listening: Paige is going to tell us about what she built.
- New vocabulary: This shape is called a cube.

(Adapted from [Questions in Block Play Can Increase Your Child's Vocabulary](#))

Block Play and Self-Regulation

Dr. Stuart Shanker (1952 -) defines self-regulation as “the ability to manage your own energy states, emotions, behaviours and attention, in ways that are socially acceptable and help achieve positive goals, such as maintaining good relationships, learning and maintaining wellbeing.” (Self-Regulation by Dr. Stuart Shanker). Dr. Shanker makes a key distinction between the concepts of self-control and self-regulation. Self-control is the ability to inhibit impulses whereas self-regulation is the ability to manage stressors. For example, a preschooler may be able to resist the urge to knock over his friend's tower of blocks. This is evidence of self-control. But why did the child feel the urge to knock over his friend's tower of blocks? Perhaps the children playing in the block area were making a lot of noise, which the child found stressful. A child who can recognize environmental factors that cause them stress can respond in a more socially acceptable way by, for example, reducing exposure to the stressor by moving to a quieter area of the room.

Supporting Block Play

Educators can support block play with the following:

- Ensure the physical environment and the classroom schedule enable uninterrupted play
- Expand on children's planning and problem-solving by asking questions
- Make suggestions when play seems to have stalled
- Comment on structures to show interest
- Protect unfinished structures so a child can return to finish
- Use mathematical and spatial terms to describe structures
- Introduce new vocabulary to describe structures
- Post photos of children's structures
- Pair a child who seems reluctant to engage in block play with a child who enjoys block play
- Encourage respectful relationships (e.g., no hoarding of blocks, no knocking down other structures, etc.)

Suggested Materials for Block Play

Table 7.2 Suggested Materials for Block Play

Type of Materials	Examples of Materials
Found or Recycled Materials	Boxes and plastic containers of varying shapes and sizes, tin cans.
Basic	Various stores purchased plastic and wooden blocks- lego, duplo, magnetic.
Enhanced	Full set of unit blocks, set of hollow blocks, additional accessories such as PVC tubes, animals, cars, coloured, and liquid-filled blocks. Storage for everyday use.
Natural Environment	Cut and sanded logs and sections. Rocks, shells, planks.
Adaptive Materials	Space is conducive to needs and educators to support- perhaps some blocks on tables and various heights. Baskets to carry blocks easily.

? Pause to Reflect

Do you see females accessing the block area regularly? Is there a different way to present blocks so all will benefit from the skills block play offers?

👉 Important Things to Remember

- Blocks provide opportunities for development in all developmental domains for all ages of children.
- The seven stages of block play are: carrying, stacking, bridging, enclosures, patterns, and representation 1 and 2.
- Block play can enhance exposure to mathematical and science concepts.
- Block play is an excellent opportunity to help children learn and build prosocial skills.
- Block play is a literacy-rich learning opportunity.

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CHAPTER OVERVIEW

8: Curriculum Planning - Learning Experience Plans

8.1: Relevant Developmental Domains

8.2: Appropriately Challenging

8.3: Culturally and Linguistically Appropriate

8.4: Effective Transitions

8.5: Wisconsin Model Early Learning Standards Framework

8.6: The Teaching Cycle

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8.1: Relevant Developmental Domains

Course Competency 8. Develop STEM learning experience plans that promote child development and learning.

Criteria: 8.1. plan incorporates relevant developmental domains (physical, cognitive, language, social/emotional).

In this chapter, we will look at the components of a learning experience plan. You will review developmentally appropriate practice, developmental domains, individual and cultural appropriateness, the use of effective transitions, the WMELS Framework and the Teaching Cycle. First, let's review developmentally appropriate practice.

Developmentally Appropriate Practice

When planning curriculum for children we must be sure the activities are developmentally appropriate. According to the National Association for the Education of Young Children's Position Statement, "The core of developmentally appropriate practice lies in... intentionality, in the knowledge that practitioners consider when they are making decisions, and in their always aiming for goals that are both challenging and achievable for children." In order to do this they must use developmentally appropriate practice (DAP). DAP includes three areas of knowledge:

1. **Age-Appropriateness** – using what is known about child development and learning in general. More specifically this means: What is known about child development and learning: Knowledge of age-related human characteristics that permits general predictions within an age range about what activities, materials, interactions, or experiences will be safe, healthy, interesting, achievable, and challenging to children.
2. **Individual-Appropriateness** – using what is known about each child as an individual to be responsive to each child. More specific examples of this include: What is known about the strengths, interests, and needs of each individual child in the group: [Necessary] to be able to adapt and be responsive to inevitable individual variation.
3. **Social- and Cultural-Appropriateness** – using what is known about the social and cultural context in which children live^[1]. This means: Knowledge of the social and cultural contexts in which children live: [Necessary] to ensure that learning experiences are meaningful, relevant, and respectful for the participating children and their families. (Bredenkamp & Copple 1997, 8–9)

Head Start has **Guiding Principles** that reflect developmentally appropriate practice by an intentional teacher.

1. Each child is unique and can succeed
2. Learning occurs with the context of relationships.
3. Families are children's first and most important caregivers, teachers, and advocates.
4. Children learn best when they are emotionally and physically safe and secure.
5. Areas of development are integrated, and children learn many concepts and skills at the same time.
6. Teaching must be intentional and focus on how children learn and grow.
7. Every child has diverse strengths rooted in their family's culture, background, language, and beliefs.^[2]

8.1 Relevant Developmental Domains

Course Competency Criteria **8.1 plan incorporates relevant developmental domains (physical, cognitive, language, social/emotional)** aligns with Developmentally Appropriate Practice Area of Knowledge number **1. Age-Appropriateness** and the Head Start Guiding Principle **5. Areas of development are integrated, and children learn many concepts and skills at the same time**. From our work with the Wisconsin Model Early Learning Standards, we know children learn in multiple domains through one activity. It also aligns with Head Start Guiding Principle **6. Teaching must be intentional and focus on how children learn and grow**.

The Wisconsin Model Early Learning Standards reflect 5 Domains of Learning

- I. Health and Physical Development
- II. Social and Emotional Development
- III. Language Development and Communication

IV. Approaches to Learning

V. Cognition and General Knowledge

Each of those domains is further divided into 3 Sub-Domains. Below you will see how the Cognition and General Knowledge Domain is sub-divided. Please see the [Wisconsin Model Early Learning Standards](#) for detailed information on each of the 5 domains.

V. Cognition and General Knowledge.....

- A. Exploration, Discovery, and Problem Solving....
- B. Mathematical Thinking.....
- C. Scientific Thinking

Observing the children in our care and looking at the developmental continuum and sample behaviors in the WMELS book will help teachers to be sure they are planning learning experiences and activities that are age-appropriate.

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[1] National Association for the Education of Young Children. (2009) Developmentally Appropriate Practice in Early Childhood Programs Serving Children from Birth through Age 8. Retrieved from <https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/position-statements/PSDAP.pdf>

[2] Head Start Early Learning Outcomes Framework by the U.S. Department of Health and Human Services is in the public domain

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8.2: Appropriately Challenging

Course Competency 8. Develop STEM learning experience plans that promote child development and learning

CRITERIA 8.2 Plan is relevant, meaningful, and appropriately challenging

8.2. Plan is Relevant, Meaningful, and Appropriately Challenging

Course Competency Criteria **8.2 plan is relevant, meaningful, and appropriately challenging** aligns with Developmentally Appropriate Practice Area of Knowledge number **2. Individual-Appropriateness**. Remember, this is using what is known about each child as an individual to be responsive to each child. More specific examples of this include: What is known about the strengths, interests, and needs of each individual child in the group: [Necessary] to be able to adapt and be responsive to inevitable individual variation.

 It Aligns with the Following Head Start Guiding Principles:

1. Each child is unique and can succeed.
2. Learning occurs within the context of relationships.
4. Children learn best when they are emotionally and physically safe and secure.

Once again, by observing the children in the group, teachers can plan learning experiences and activities that are individually appropriate for the group of children and individual children in the group by noticing their interests and developmental levels. Remember the Zone of Proximal Development (ZPD) from Vygotsky. Children learn best when the activities and learning experiences are just slightly above their current level of development and they have the guidance and support of a More Knowledgeable Other (MKO), meaning we don't want the activities to be too easy or boring for them or overly difficult or too challenging for them.

To begin to understand how to plan effective, developmentally appropriate curriculum for children, we must look at the context in which that planning should happen. Planning everything, from the flow of the day, to how teachers design and stock the classroom environment, to the way the spontaneous (unplanned) experiences of children are recognized and valued, to the experiences teachers thoughtfully plan and intentionally implement, happens in a continuous cycle. As we will discuss in this chapter that cycle begins with observing and continues through documenting what was observed, reflecting on what it means and how to plan to best support children, and then implementing those plans, before returning back to observing.^[1]

Planning curriculum for young children begins with teachers discovering, through careful listening and observation, each child's development. Observation is an essential skill for a teacher. When teachers mindfully observe, they discover how individual children make meaning in everyday moments of play and interactions and how to deepen their relationships with children. Observing for the purpose of assessing individual children's learning means carefully watching and listening, with thought and reflection. In doing so, teachers find the knowledge, awareness, and strategies that individual children have formed during their experiences. It may be evidence that pertains to individual children's emotional, social, cognitive, or physical development. If the evidence is clear and significant, teachers can preserve it through, for example, a note, a photo, or a sample of a child's work.

Consider this example in which teachers found various ways in which the children's engagement in learning about snails related to the developmental profiles of different children:

Vignette

As the children's interest in the snails continued, the teachers looked for ways to expand learning opportunities and integrate them into the multifaceted experience. The teachers also reviewed individual children's developmental profiles to be mindful of children's developmental progress in different areas. In addition to the many counting opportunities in the environment, the teachers decided to integrate counting into the children's exploration of snails. Younger children who were making progress with learning to count objects between five and ten were invited to set up a specific number (less than ten) of trays and snails.

Before the children started, the teachers reminded them of an earlier conversation about how to care for snails. In response, one of the children asked to show the others how to handle the snails gently. (Learning about counting was happening at the same time as learning about controlling the impulse to handle other creatures roughly instead of being gentle with them.) Teachers suggested to other children who were continuing to make progress with counting to count out a quantity of sticks, bark, or leaves greater than ten. Other children were asked to divide the snails evenly between the trays. The children kept saying to themselves, “Be gentle,” and handled the snails with great care.

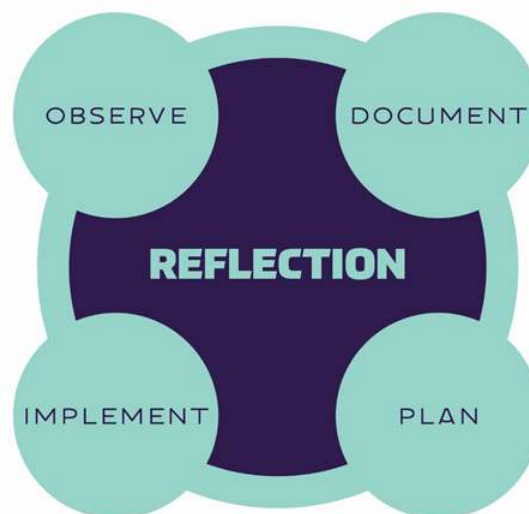


Figure 8.1: Handling the snail carefully.[2]

As teachers observed each group, they helped children develop mathematical thinking by prompting them and asking questions. For example, at one table, a teacher noticed that children were counting some sticks twice. She said, “I wonder what would happen if we put each stick on the other side of the tray after counting it.” The children tried out this idea. Teachers noted children’s efforts and placed the notes, with the date recorded, into the children’s individual portfolios to be used as evidence for later reference when considering developmental progress relating to number sense and impulse control.

As teachers observe children’s play and interactions, they discover ways to support children’s learning. Ideas for the next steps in curriculum planning emerge as teachers reflect on how they might extend or expand children’s thinking, language, and interactions. Observation, reflection, and documentation in the moment simultaneously launch an ongoing assessment of each child’s progress in learning as well as the curriculum planning cycle.[3]

Here is a visual representation of the Curriculum Planning Cycle



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8.3: Culturally and Linguistically Appropriate

Course Competency 8. Develop STEM learning experience plans that promote child development and learning

CRITERIA 8.3. plan is developmentally, culturally, and linguistically appropriate for the age group.

Course Competency Criteria **8.3 plan is developmentally, culturally, and linguistically appropriate for the group** aligns with: the Developmentally Appropriate Practice Area of Knowledge number **3. Social- and Cultural-Appropriateness** – using what is known about the social and cultural context in which children live^[1].

This means: Knowledge of the social and cultural contexts in which children live: [Necessary] to ensure that learning experiences are meaningful, relevant, and respectful for the participating children and their families. (Bredekamp & Copple 1997, 8–9)

It aligns with the following **Head Start Guiding Principles**:

- 3. Families are children’s first and most important caregivers, teachers, and advocates.**
- 7. Every child has diverse strengths rooted in their family’s culture, background, language, and beliefs.**^[2]

Curriculum in Multicultural Classrooms

The term culturally responsive practices has been used to refer to the implementation of effective teaching practices in diverse early education settings. Culturally responsive practices are teaching to the individual needs of children who are culturally, ethnically, and linguistically diverse. This term implies the integration of assessment and curriculum practices: program staff must learn about the individual abilities and preferences of each of the children enrolled in their program, and then find ways to plan and implement a curriculum that is based upon each individual child’s needs and interests. For example, teachers can use home visits to learn about the child, to observe ways that families interact with their child, and to begin a dialogue with families about their goals for the child.

Classroom Materials

In her 1995 book, *The Right Stuff for Children Birth to 8*, Martha Bronson offers detailed suggestions for selecting play materials that are safe, appropriate, and supportive of play and development. It is relevant to note here that classroom materials can potentially depict people in stereotypical ways or only contain simplified or inaccurate images of culturally diverse people. Therefore, the challenge is to provide classroom materials that reflect all children, families, and adults in the program, and to eliminate stereotypical or inaccurate materials from daily use. For example, books and dramatic play materials should reflect diversity of gender roles, racial and cultural backgrounds, special needs and abilities, and a range of occupations and ages. Books and environmental print should also represent the different languages of children in the classroom.



Figure 8.2: What diversity is represented in this image of children and dolls? ^[50]

The challenge for programs is to establish systems and procedures that take the cultural and linguistic contexts of the children into account. Once in place, these classroom materials should be reviewed on an ongoing basis to ensure that the classrooms reflect all enrolled children without stereotyping. Programs are encouraged to seek information from families and knowledgeable members of the community for their input in equipping classrooms to reflect cultures and languages in respectful ways.

Finally, encouraging children’s language and cognitive growth does not preclude the responsibility to support each child’s sense of wellbeing, the formation of his or her identity, and feelings of security. A consensus within the research is that effective environments for children support all domains of development, and that environments associated with learning outcomes should

also provide strong support for social–emotional development (Hart & Risley 1995, 1999; National Research Council and Institute of Medicine 2000; Snow, Burns, & Griffin 1998).

With this in mind, the developmentally, culturally, and linguistically appropriate environment mirrors the ideas, values, attitudes, and cultures of the children it serves (Gestwicki 1995). The following are some specific strategies suggested by Derman Sparks (1989):

✓ Suggested Strategies

1. Use images in abundance that represent all children, families, and staff in your program.
2. Use images of children and adults from the major ethnic groups in your community and in U.S. society.
3. Use images that accurately reflect people’s current daily lives in the U.S. during work and recreational activities.
4. Offer a balance among different cultural and ethnic groups.
5. Provide a fair balance of images of women and men doing “jobs at home” and “jobs outside home.” Provide images of older people of various backgrounds doing different activities.
6. Provide images of differently abled people of various backgrounds at work and with their families.
7. Use images of diversity in family styles, such as single mothers and fathers, and extended families that are multiracial and multiethnic.
8. Use images of important individuals, past and present, and that reflect diversity.
9. Exhibit artwork—prints, sculpture, and textiles—by artists of various background

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8.4: Effective Transitions

Course Competency 8. Develop STEM learning experience plans that promote child development and learning

CRITERIA: 8.4 Plan includes effective transitions

Effective Transitions

Transitions that are effective will:

1. Make your day flow smoothly.
2. Gain the children's attention or interest.
3. Help you to give directions about what is coming next or how the children should do something.
4. Help you move the children from one activity to another in an orderly fashion.
5. Transitions can also help you to assess what they children have learned.

Types of Transitions for Your Learning Experience Plans

1. Gaining Attention and/or Interest: You will want to plan a transition for your introduction to your activities that will gain the children's attention and entice them to want to do the upcoming activity. Some ideas for this include songs or fingerplays related to the activity, surprise boxes or bags, puppets, drawing their attention to previous learning and helping them make a connection to the new learning that will occur in the activity.

An effective transition gains their attention and focus. It is interesting and helps the children to be excited about the upcoming activity. This is an example of what an effective transition is **NOT**. Telling the children "Ok, we are going to read a story", or "We are going to do this activity.", or "Who wants to...."

Please review Module 2 in the Canvas Course and review [Chapter 2.2 Transitions](#) in this text to review information on transitions.

2. Dismissal Transition: You will be planning a dismissal transition from your activity to the next activity in the day or from the directions part of your activity to the area they will go next to complete the next part of the activity.

You can use this as a time to assess what the children have learned by asking them a question. You will ask the children a question, one at a time. Once the child answers, they are dismissed to the next activity.

Please be thoughtful and intentional in your transition activities. It is best when you can connect them to the learning or theme of the activities they are doing.

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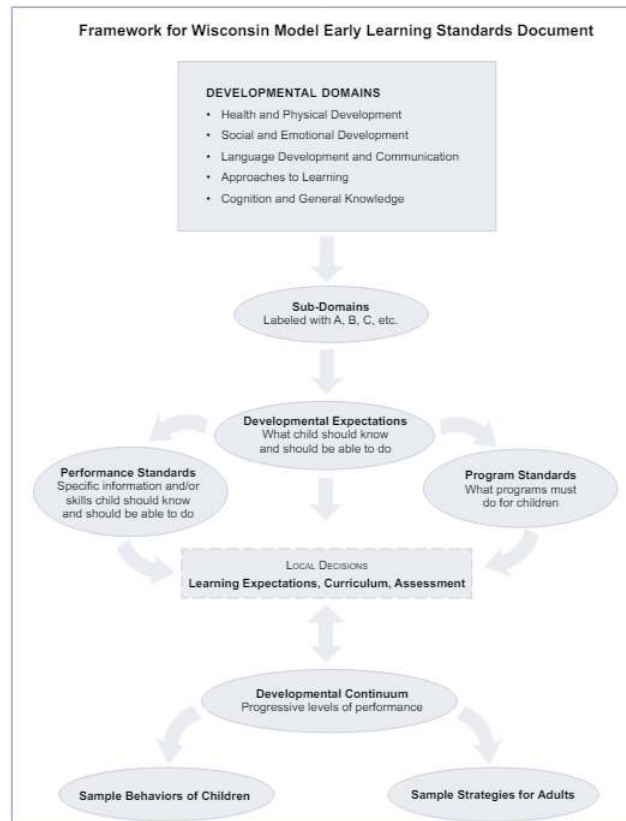
8.5: Wisconsin Model Early Learning Standards Framework

Course Competency 8. Develop STEM learning experience plans that promote child development and learning

CRITERIA: 8.5. plan incorporates the WMELS Framework.

WMELS Framework

Please see page 2-3 of the [Wisconsin Model Early Learning Standards](#) to learn more about the framework.



Text:

"Framework for Wisconsin Model Early Learning Standards Document:

Box 1: "Developmental Domains"

Items:

- Health and Physical Development
- Social and Emotional Development
- Language Development and Communication
- Approaches to Learning
- Cognition and General Knowledge"

Flow down to Circle 1: "Subdomains: Labeled with A, B, C, etc."

Branches down to three sub-circles:

1. "Performance Standards: Specific information and/or skills child should know and should be able to do"

2. "Developmental Expectations: What child should know and should be able to do"

3. "Program Standards: What programs must do for children"

Flow to Box Two, with dashed borders: "Local Decisions: Learning Expectations, Curriculum, Assessment"

Down to Circle 2: "Developmental Continuum: Progressive levels of performance"

Down to two sub-circles:

1. "Sample Behaviors of Children"

2. "Sample Strategies for Adults"

The WMELS Framework is built in to your lesson plan form for your learning experiences. You will be including:

1. The Domain
2. The Sub-Domain
3. The Performance Standard
4. The Developmental Continuum
5. Sample Behaviors of the Children and how they align or relate to your activity.

You will also be including the Relevant Developmental Domains for your activity as we know children develop in multiple domains at once. See [8.1 Relevant Developmental Domains](#) to review.

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8.6: The Teaching Cycle

Course Competency 8. Develop STEM learning experience plans that promote child development and learning

CRITERIA: 8.6. Plan reflects the teaching cycle.

In section 8.2: [Appropriately Challenging](#), we were introduced to one type of teaching cycle that is similar to the Wisconsin Model Early Learning Standards Teaching Cycle. Both cycles start with observation. Teachers want to know the skill levels and interests of the children to plan their curriculum. Teachers observe and document interests and skill levels. Teachers then review their observation data to intentionally plan learning experiences that meet the developmental needs and interests of the children. Once they have planned and developed the learning experiences, they implement the activities with the children and the entire cycle begins again. As teachers implement the learning experience with the children, they observe and document to see how the children are developing and what they may need extra experience or practice in. Teachers use their observations to plan additional learning experiences to meet the needs of the children

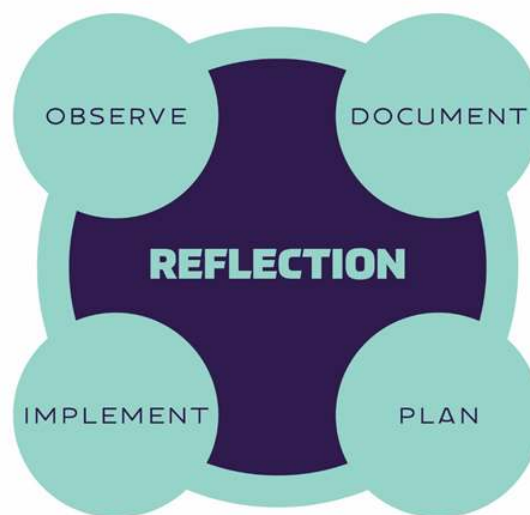


Figure 8.2: The California Curriculum Planning Cycle.[4]

Let's explore each part of the cycle.

Observe

Observation means being present with children and attentive as they play and interact with others and the environment. This mindful kind of presence is different from participating in children's play or directing their play. Whether for one minute or five, an attentive, mindful presence means waiting to see what unfolds in order to gain a complete picture of children's play. A teacher who observes children as a first step in supporting learning discovers small scientists at work—experimenting, comparing, making assumptions, evaluating assumptions through their actions. Over time, children build mastery of a wide range of concepts and skills. The vignette about the snail exploration illustrates the role of the teacher as observer:

During small-group time with the snails, the teacher noticed a child who had been reluctant to hold a snail. This child had a visual impairment. As the teacher gently placed a snail on this child's hand, two children watched and listened as the teacher commented, "He's sticking his head out now, and he's turned toward your fingers. Can you feel him crawling toward your fingers?" The other children who had been watching intently began to repeat the teacher's encouraging words, saying, "He's sticking his head out. He's going toward your fingers!"

The teacher wrote down her observations and added an interpretive note that the children's behavior may be a growing sign of empathy as measured by the DRDP, and the other child's willingness to hold the snail, a growing sign of curiosity and initiative, also a DRDP measure.[5]

Observation Happens Through Lenses

It takes practice to become a good observer. An important aspect of being a good observer involves becoming aware of what is noticed and how observations are interpreted. Children may be influenced by many things. Culture, temperament, personal experiences, professional knowledge, and even community values and messages in the media affect how teachers see and experience children. These “lenses” through which teachers observe and interpret are at work even though they may not always be conscious of them.[6]

The Importance of Accuracy

Observations about children should be factual and objective to be useful and meaningful. Teachers should document only what they see and hear (the facts) and avoid using words that communicate judgment about a child’s feelings, intentions, and motivations; are ambiguous and open to interpretation; or describe an opinion. One way teachers may think about their own objectivity is to ask themselves: Am I describing this child’s behaviors and interactions in the same or a similar way that someone else observing this child would describe them?

Interpreting the meaning of children’s behaviors and interactions is important, and impressions, feelings, and insights about children are extremely valuable to the individualizing process. However, teachers first need accurate, factual information in order to draw conclusions later on about children’s skills, behavior, interests, and needs.[7]

Pause to Reflect

Think about yourself as an observer. What do you think will come most easily to you? What do you think will be more challenging?

Document

Documenting means gathering and holding evidence of children’s play and interests for future use. A common form of documentation in early childhood settings is a written note, often referred to as an observation anecdote. Anecdotal notes, along with other forms of documentation, in particular photos, video recordings, and work samples, serve a dual purpose. First, they preserve a teacher’s observations of children’s expressions of feelings, their thinking, and their learning. These documentations are guides to the next steps in day-to-day curriculum planning. And second, anecdotal notes and other evidence can be used to support a teacher’s periodic assessment of a child’s progress. An episode during the snail exploration highlights the dual purpose of documentation:



Figure 8.3: Holding a snail.[8]

During their initial encounters with the snails, the children asked questions and made comments about the snail shells, the way the snails moved across the tray, and what the snails ate. Although several children were reluctant to pick up the snails, others were challenged by having to wait. The teachers recorded children’s distinct responses, writing down significant elements of what children said or did. For example, for a child with identified special needs related to self-regulation, a teacher noted: “Jasmine pushed aside Yuri in order to pick up the snail crawling off the tray. Yuri stumbled, fell, and began to cry. Jasmine continued to focus on the snail, saying nothing to Yuri.” For the teacher, Jasmine’s behavior was significant. This anecdotal note provided some evidence of Jasmine’s struggles with impulse control. It added to the growing evidence that Jasmine was still developing impulse

control and empathy. Later, as the teacher shared her observation with her co-teacher and with Jasmine's father in a conference, they discussed how the small group work around keeping the snails safe might support Jasmine as well as other children in reading cues of others and in thinking before acting in order to keep people safe.[9]

Documenting What is Observed

Teachers must be intentional about capturing and recording what children do and say by setting up a system for carrying out observations. There is no one right way to do this. Systems will look different from program to program, and even classroom to classroom. Additionally, observation systems are not static; they should be revisited as teachers become more proficient in observing children and as children grow and develop. However, there are some general strategies that should be considered when developing a system.

- Plan times to observe each child regularly and over time. This should include observing children
 - Across settings (e.g., indoor and outdoor) and times of the day (morning, afternoon)
 - During routines (e.g., mealtimes, naptime, arrival/departure, transitions)
 - As they engage in spontaneous play experiences and planned activities and experiences
 - As they interact with other children and adults.
- Plan for spontaneous observation opportunities, too.
- Have materials at hand to capture unexpected, but valuable observations of children.
- Decide how to organize and store observations with the system that works best for the individual teacher or teaching team. For example:
 - A file folder for each child kept in hanging files in file cabinet, large box, or crate
 - Index cards in file box with a section for each child
 - A 3-ring binder notebook for each child
 - An accordion folder for each child
 - Hanging shoe bag, with pockets labeled for each child
- Decide how often to review observations. A system for using the valuable data from observations is an important part of the curriculum cycle. Some curriculum planning may be easy to implement based on just casual observation. But deeper analysis of observation of individual and groups of children will likely lend valuable insight in what teachers can plan to support optimal development.
- Include families in this process. Invite them to share what they observe about their children verbally, through pictures and photographs, or in writing.

Reflect & Plan

As teachers reflect on children's play, they discover possibilities for designing curriculum to sustain, extend, and help children's play to be more complex and, consequently, support the children's continuing learning.[13]

Teachers ask themselves questions about what the information they have documented in observations of children says about the children's development, interests, and needs. The answers to these questions lead to individualizing care and learning. There are many questions that teachers may ask themselves. For example:

- What developmental skill or activity does the child appear to be working on?
- What strategies does the child use to play with different toys?
- Does the child engage with objects or people differently than a month ago? What has changed? What has not changed?
- Do my actions/the actions of other adults who interact with the child affect the outcomes of the child's experience? How so?
- How does the information relate to goals for the child? The family's goals? The program's school readiness goals?
- What other information do I need?
- What questions do I have for the child's family?

It is during the reflective process that interpreting the meaning of children's behaviors and interactions becomes important. These interpretations and insights give rise to each child's story. Each child's story informs responsive practice.

Teachers use what they know about each child to

- Adapt the environment
- Modify the daily schedule and/or routines
- Make decisions about how to guide the children's learning based on what the child knows and can do as well as what the child is ready to try.[14]

That process of reflections then informs possible next steps in the curriculum. Possible steps might include adding materials to interest areas, books to read with large or small groups, activities to do in small groups, or a topic to investigate over time with the children. With clear ideas or objectives in mind, teachers plan curriculum that includes strategies to enhance the learning of all children in a group, as well as strategies to support the learning of individual children. Here is how reflection, discussion, and planning worked in the snail exploration:

While the children were exploring snails, teachers met each week to reflect and plan for the next steps in the children's explorations. They decided to schedule time for small groups of children to explore the snails in a more focused way, hoping to extend the children's learning and add complexity. The teachers planned a series of walks that would allow all the children to find snails in natural habitats.[15]

Pause to Reflect

Think back to something in your childhood that you were passionately interested or engaged in that someone observing you could have documented. What questions could your teachers have asked themselves about your experiences? How could they have planned?

(If it's easier or more relevant, you can think of a child you know and consider what you can ask yourself and plan around what you know about that child.)

Implement

Once a plan is written, teachers implement it. While implementing a plan, teachers observe, reflect, and document. The curriculum-planning cycle begins again (or continues) as teachers watch to discover how children respond to the planned curriculum and how children show evidence of their development during the planned learning encounters. Teachers often approach this step with a sense of wonder, for they may be surprised and amazed by the children's responses.

To hold the responses in memory, teachers may record notes, take a photo, or label, date, and keep a work sample, all of which they can later review to assess the impact of the curriculum plans. The evidence collected will help teachers to come up with ideas for supporting and assessing the children's learning. Teachers might ponder the following questions:

- Are children responding as predicted, or were there surprises?
- What do the children's responses tell us? How might we name the children's interest(s) or intention(s)? What concepts and ideas are the children forming within their play?
- How might children who are English learners and children who speak English collaborate in small groups to learn from one another?
- Are children showing evidence of progress on any of the measures of the DRDP?

Here is what happened when the teachers implemented their idea of going on walks with the children to find snails in natural habitats:

Before going on their snail hunt, a small group of children gathered on a blanket with the teacher. Each child was provided with a clipboard with paper for taking "notes" while the teacher explained how the walk would be a way to find snails that lived outside their classroom. Some children pretended to write while the teacher talked, while others drew pictures of snails. In this group, teachers included two children who were fluent in Spanish and learning English. The teachers anticipated much conversation among children during the search for the snails and wanted to give these children a chance to converse in their home language as well as to share experiences with peers who spoke only English.

Before heading off on the hunt, the teacher suggested, "Let's estimate. How many snails do you think we will find? Each of you can guess." On a large sheet of paper that the children could easily see, she wrote each child's name, saying each letter as she did so,

and next to each name, the number guessed by that child.

Armed with magnifying glasses, the children went off to collect snails. There were many discoveries along the walk, not just snails. As children found snails, they carried them to a large examination tray set up on a table. Some children took a break from their snail search to examine, touch, and draw the snails already collected. At the end of the hunt, the children lined up the snails on a small log and counted them. The teacher suggested that they compare the number they counted with their estimates.

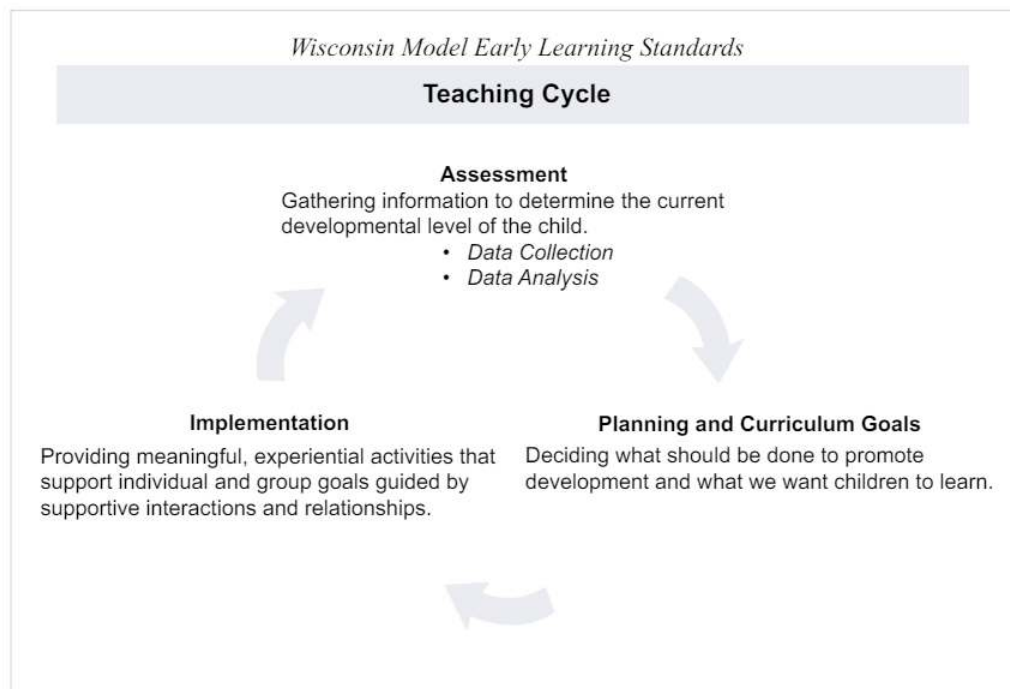
Before returning to their classroom, the children put the snails back into their natural habitats. The children were excited about sharing their experiences with other teachers and peers when they returned.

The teachers examined and reflected on what they saw in the children's writings and drawings on the clipboards. They decided that some of the work samples were significant in showing how individual children were developing an idea, concept, or skill. They filed those samples in the children's portfolios as evidence of developmental progress.^[18]

Pause to Reflect

What happens when implementation goes differently than expected? What would have happened if the children had discovered and become fascinated with dandelions on their hunt for snails (and subsequently lost interest in the snails)? Does curriculum have to go as planned? Why or why not?

The Wisconsin Model Early Learning Standards Teaching Cycle



You will notice that the WMELS Teaching Cycle is similar, however, it only has three parts: Assessment, Planning and Curriculum Goals, and Implementation.

The first stage of the WMELS Teaching Cycle, **ASSESSMENT**, correlates to the first two stages of the California Curriculum Teaching Cycle: Observe and Document.

The second stage of the WMELS Teaching Cycle, **Planning and Curriculum Goals**, correlates to the third stage of the California Curriculum Teaching Cycle: Plan.

The third stage of the WMELS Teaching Cycle, **Implementation**, correlates to the fourth stage of the California Curriculum Teaching Cycle: Implement

See page 9 of [WMELS](#) for more information

References

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CHAPTER OVERVIEW

9: Curriculum Planning - Interdisciplinary Units

[9.1: Sequential Learning Experiences](#)

[9.2: Address All Developmental Domains](#)

[9.3: Experiences from All STEM Content Areas](#)

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9.1: Sequential Learning Experiences

Course Competency 9. Integrate STEM learning experiences into an interdisciplinary unit

CRITERIA: 9.1. unit plan includes multiple sequential learning experiences

It is common for many programs to integrate many aspects of learning with the use of “themes” as a way to weave learning together for children. For some learners, the connection of several learning experiences all related to a common concept can support deeper learning. The most successful themes are those that emerge out of the children’s interest (often called “**emergent curriculum**”). Common themes include:

- My family
- Friendship and caring
- Community Helpers
- Animals
- Activities (camping, ...)
- Transportation
- Locations (oceans, mountains, farms,...)



Pause to Reflect

What other themes can you think of?

What themes can you think of that will allow you to present science and math topics to the children?

Often when planning a theme, teachers will use the concept of a curriculum “web” to begin to plan their ideas. Like a list, but in a different format, a web allows teachers to brainstorm related ideas and then to choose the ones that make the most sense to more thoroughly plan for. This process uses both a teacher’s divergent and convergent thinking skills.

A basic web diagram will look like this:



Figure 9.1: Basic web diagram

Here is a sample of a curriculum web using this format. Can you think of activities to add?



Figure 9.2: Sample curriculum web

Pause to Reflect

What advantages can you find in creating a planning web?
How might you incorporate children into helping you web ideas?



Interdisciplinary STEM Units

In Chapter 8 you learned about writing individual learning experience plans for Science and Math. Previously, in chapter 9, Part 9.1 Interdisciplinary Units, you learned about creating a curriculum web to plan an interdisciplinary unit. When planning units we will want to be sure we include each of the criteria list above. The unit must include multiple sequential learning experiences, address all the developmental domains, include Science, Technology, Engineering and Math experiences, and meet all the requirements for learning experiences plans.

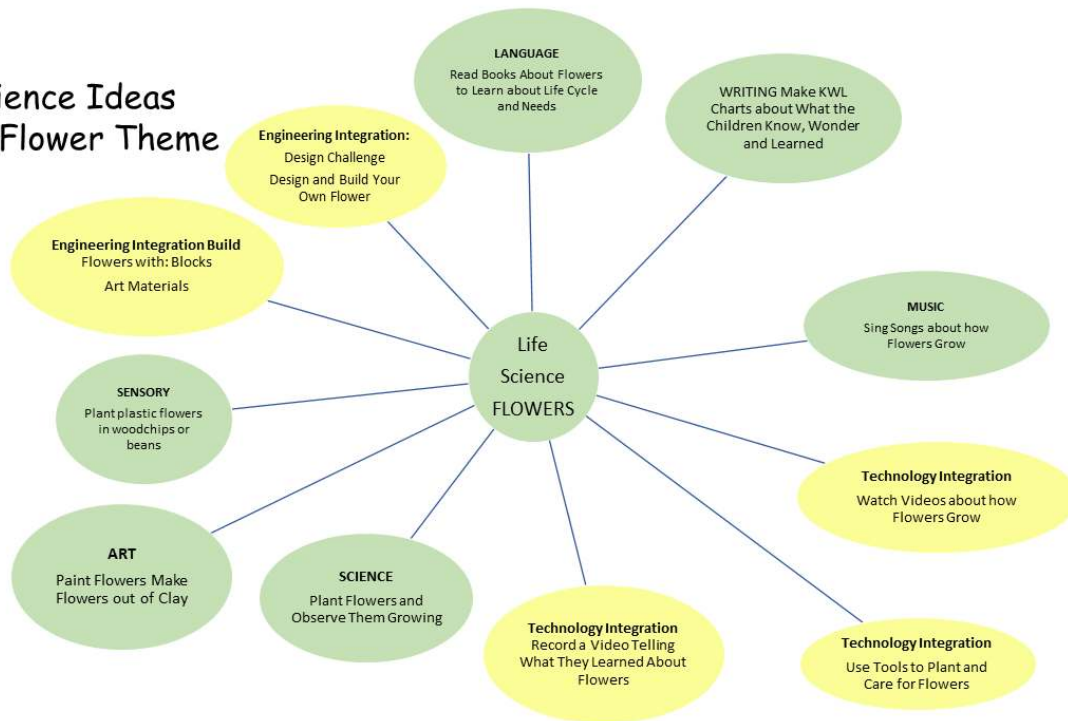
Curriculum Web for Science and Math

Below are webs outlining an interdisciplinary STEM unit that combines Science and Math activities, integrated with Technology and Engineering components.

When planning, teachers should always take into account the interests and developmental level of the children. For example, a teacher could plan a Flower theme if they observe the children taking great interest in the flowers and plants growing outside. Children learn best when the activities in the classroom are integrated, meaning all the activities the teacher plans are related to the same topic.

First, we will take a look at Science.

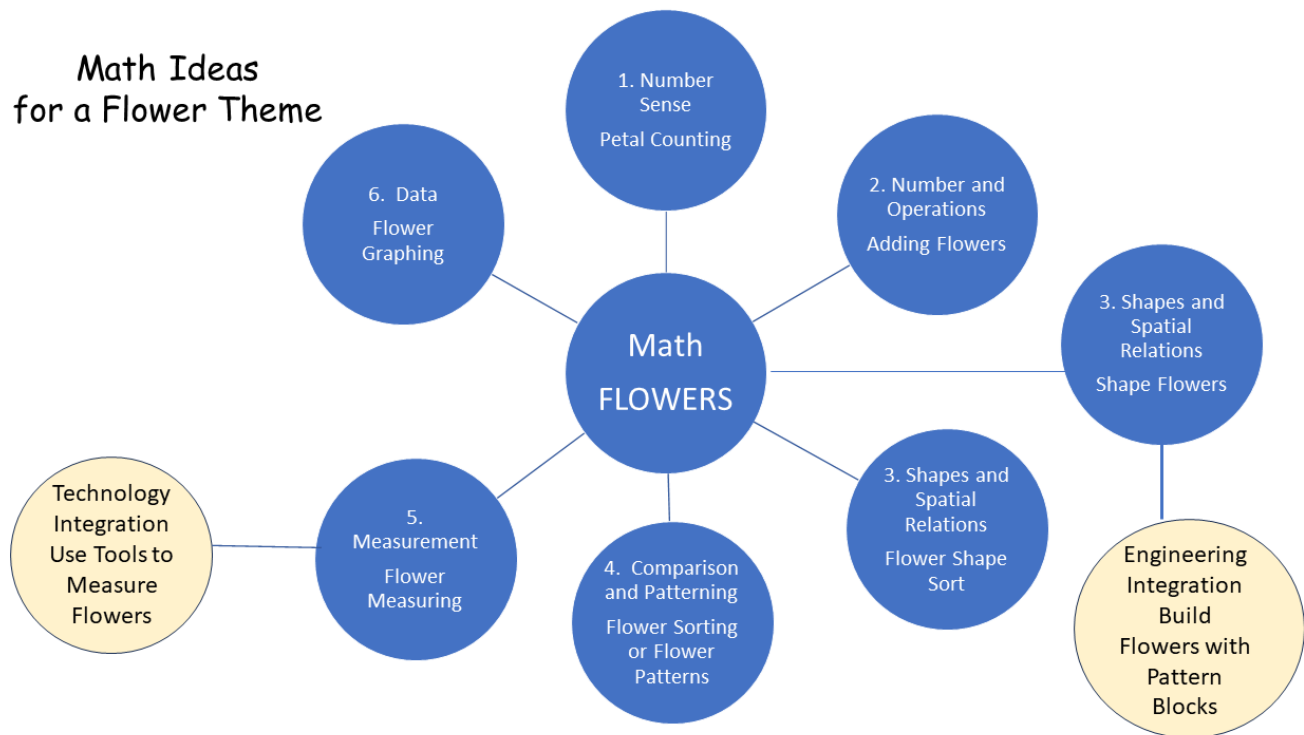
Science Ideas for a Flower Theme



1. Start with a theme. In the example the theme is FLOWERS.
2. Determine the type of science topic the theme is (Life, Physical, Earth and Space). Flowers is a LIFE science topic.
3. Determine activities for the various areas or centers in your classroom that would help the children develop skills and understandings relating to flowers.
4. Determine ways Technology and Engineering can be integrated into the activities in the centers.

Now let's look at how you could plan math activities for a flower theme that will help children learn skills in each of the areas of mathematical education addressed in the Wisconsin Model Early Learning Standards.

Math Ideas for a Flower Theme



1. Start with a theme. In the example the theme is FLOWERS.
2. Determine activities that will help the children learn skills and understandings in each of the mathematical areas:
 - Number Sense
 - Number and Operations
 - Shapes and Spatial Relations
 - Algebraic Thinking: Sorting, Patterning, and Reasoning
 - Measurement
 - Data Analysis: Graphing

3. Determine ways engineering and technology can be integrated into the math experiences.

As you can see all of the activities shown in the science and math web are examples of multiple sequential learning experiences.

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9.2: Address All Developmental Domains

Course Competency 9. Integrate STEM learning experiences into an interdisciplinary unit

CRITERIA: 9.2. unit plan addresses all developmental domains

Domains of Learning

“Development” and “learning” are two integrated concepts that we promote as teachers. As children are “learning” new concepts and skills, they are fostering their “development”. Our goal is to encourage the development of the “whole child” (physical, cognitive, social, emotional, spiritual) by providing learning experiences based on children’s interests and abilities, a concept known as “**intentional teaching**”.

Although children learn in an **integrated** manner (blending all areas of development together) these areas are often broken down for planning purposes.

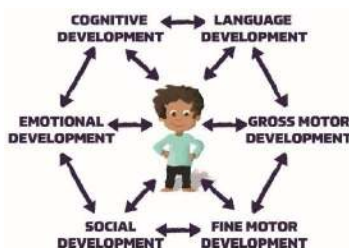


Figure 9.3: All areas of development affect and are affected by each other ^[69]

Table 9.2.1 below shows the relationship between the domains of development and concepts of learning.

Table 9.1: Relationship between Development and Learning ^[70]

Development	Learning
Cognitive	Science, Technology, Math
Language	Language and Literacy
Physical	Health, Safety, Nutrition, Self-Help Skills, Physical Education
Social, Emotional, Spiritual	Social Science, Visual and Performing Arts

Vignette

Javier and Ji are playing in the block area. They have stacked several large blocks on top of each other. Twice the blocks have fallen and each time they have modified their plan slightly to make them stay. Once stable, Ji counts the blocks and Javier turns to the teacher and proudly says, “Look at our 5-story building, you should shop here.”



Pause to Reflect

Can you find development and learning for Javier and Ji in each of the categories listed in the table above?

Including All Domains in Unit Plans

You will want to be sure that the activities you have planned for your interdisciplinary unit will foster development in all developmental domains.

See the images below for examples of how the children might be developing in all domains through the activities in the unit.

Addressing All Developmental Domains

- You will want to be sure the activities in your unit plan a helping the children to develop in all domains.
- Most of the time children are learning in all domains through one activity.
- You will want to think about each activity to see what domains a child will be developing in to be sure you have included all domains. See examples of some ways children will be developing by participating in activities in the flower unit.

Health and Physical Domain

- Children will develop fine motor skills through creating flowers with art materials or with blocks.
- Children will develop fine motor skills through planting seeds and flowers.
- Children will develop fine motor skills through using tools to take care of plants.

Social and Emotional Domain

- Children will develop social emotional skills as they take turns using materials.
- Children will develop social emotional skills when they share what they are learning with others.

Language Development and Communication Domain

- Children will develop language and communication skills through listening to stories.
- Children will develop understanding of theme related vocabulary through stories and discussions.
- Children will develop beginning level skills in reading as they see theme related words in print.

Cognition and General Knowledge Domain

- Children will develop social emotional skills as they take turns using materials.
- Children will develop social emotional skills when they share what they are learning with others.

Approaches to Learning

- Children will develop language and communication skills through listening to stories.
- Children will develop understanding of theme related vocabulary through stories and discussions.
- Children will develop beginning level skills in reading as they see theme related words in print.

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9.3: Experiences from All STEM Content Areas

Course Competency 9. Integrate STEM learning experiences into an interdisciplinary unit

CRITERIA: 9.3. Unit plan includes experiences from the following areas: Science, Technology, Engineering, and Math

Incorporating All STEM Content Areas



You will want to be sure your unit plan includes activities from all the STEM content areas: Science, Technology, Engineering and Math. Of course, to make it a truly interdisciplinary unit you will want to incorporate your theme in other content areas such as Art, Music, Language, and Social Studies.

You will want to integrate multiple domains and content areas into your activities because children learn better when learning is connected. Let's look at 2 examples below. One is for a theme about Spring Things and the other will be about Flowers.

Separate, Unconnected Learning Experiences for Spring

✓ Separate Learning Experiences

Theme: Spring

Story: Spring is Here: A Bear and Mole Story by Will Hillenbrand

Writing: Teacher writes a class chart about the children's favorite thing to do in the Spring

Children make a Spring Words book at the Writing Center

Science: Plant Flowers then take them home once they start to grow

Music: Sing Five Little Speckled Frogs

Art: Paint Pictures of a Duck Holding an Umbrella with Raindrops

Math: Counting Eggs in Nests

All of these activities connect to Spring, but they don't all connect to one another. They don't allow the children to go deeper into a subject and explore it in many ways.

✓ Interdisciplinary Connected Learning Experiences

Theme: Flowers

Story: Fiction—**Grow Flower Grow** by Lisa Bruce

Non-Fiction—**I Can Grow a Flower** by DK and **Tools for the Garden** by Mari Schuh

Writing: Teacher and students write a KWL chart about what the children know, what to know, and learned about flowers.

Teacher and students write/draw charts about things flowers need and their parts.

Children can make a book about the parts of a flower at the writing center.

Science: Plant Flowers and other plants: Observe them grow using tools like magnifying glasses and journal their observations. Plant and care for them using garden tools.

Music: Sing songs about flowers, their parts and how they grow. Have flannel pieces or magnet pieces for the students to sing and retell the story.

Art: Children use various art materials to create flowers.

Math: Children can count flowers, add flowers, sort flowers by color, measure flowers and graph their favorite color of flower.

Engineering Integration: Children will have opportunities to use loose parts and blocks as well as other materials to make flowers.

Technology Integration: Children will use tools to plant and care for their plants. Children will play games on an Ipad about parts of a plant and needs of a plant.

Design Challenge: At the end of the unit, the children will use what they know to design a flower with an ABAB pattern for the petals.

They will make the flower with various materials in the classroom.

They must show parts of a flower and what a flower needs.

The children will videotape themselves explaining how they made their flower, what it needs and its parts.

This project integrates all STEM disciplines and the children are learning in many domains.

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