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Computational Thinking in K-2 Classrooms: Evidence from Student Artifacts (Fundamental)

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Computational Thinking in Kindergarten: Evidence from Student Artifacts (Fundamental)

Abstract

Integrated learning is fundamental in the current era of STEM education. However, articulating evidence of learning in such complex learning environments can be a challenge. This is especially true in elementary grades where developmentally-appropriate practices are not fully defined and understood yet. One of the newest additions to the integrated STEM discussion is computational thinking (i.e., STEM+C). The purpose of this research is to explore computational thinking practices in one Kindergarten classroom during the implementation of an integrated unit. Student artifacts were collected, de-identified, and analyzed for understanding of computational thinking. Using artifact analysis, student worksheets and prototypes designed were examined for evidence of computational thinking competencies prompted by the STEM+C lesson units. This paper provides evidence of how kindergarten students engage with computational thinking through analysis of student work. Students successfully convert an existing color pattern into letters but have difficulty writing a complete pattern with repeatable units. Students also reveal difficulty with pattern abstraction as evident from prototypes designs that mismatched with their selected patterns design.

Background

Computational thinking is one of the fundamental competencies in the current era of integrated science, technology, engineering, and mathematics (STEM) education. However, articulating evidence of learning in such complex integrated learning environments can be a challenge. This is especially true in elementary grades where developmentally-appropriate practices are not yet fully defined and understood.

Computational thinking incorporates common practices with other STEM disciplines. Computational thinking as not simply programming but the overlap between mathematical thinking and engineering thinking.[1] In this paper, we investigate computational thinking and practices in Kindergarten classrooms with children approximately four to five years old. These early ages are when children are able to recognize patterns and engage in early computational thinking.[2,3]

One of the essential questions on computational thinking in K-12 education is, "what does learning to think computationally looks like in the classroom, among young learners?" [4] A part of this question is being able to observe and identify when children are practicing computational thinking, computationally. One recommendation when studying computational thinking is the collection of multiple sources of information.[5] These could include performance assessments targeting specific competencies such as algorithmic thinking and abstraction, computer log data in the case of programming a game, and analysis of student artifacts.

Computational Thinking in Elementary Schools

Computational thinking has recently gained attention in K-12 education given the growth of technology and digital computers in the 21st century and the demands for employees with computer science skills.[6] Computational thinking as introduced by Wing is more than programing and coding.[1] It is a way human think in order to solve their problems. This process requires understanding problems and solutions through fundamental concepts of computer science such as abstraction and decomposition[1]. In other words, CT is a thought process that helps develop mental tools and skills to solve complex problems of the 21st century. To formulate and solve these complex problems, CT combines critical thinking skills with the power of computing, sometimes using computers or other tools, to find innovative solutions and make good decisions.[6,7] Everyone should be able to make good decisions to perform better in this technology-based world. Therefore, computational thinking is required to solve real-life problems.

Computational thinking does not occur naturally and requires training.[8] Lu and Fletcher argued that computational thinking occurs not only in computer sciences, but in many K-12 grades, in particular elementary grades, including courses such as mathematics, biological and physical sciences, and social sciences and humanities.[9] They stated if training and practices are included in early years of education, by the time children get to high school computational thinking becomes the second nature for them. Therefore, CT should be incorporated as early and often as possible.[9] Moreover, in her seminal paper, Wing called CT a core ability for children necessary to reading, writing and arithmetic which should be added to children's analytical ability.[1] Although scarce, there have been some studies exploring computational thinking in elementary grades. These studies have argued for elementary teacher preparation and integration of computational thinking in elementary courses like mathematics, literacy and engineering.[5,8,10,11] However, more studies are needed to examine how computational thinking is demonstrated in elementary students.

Research Purpose

The purpose of this study is to explore computational thinking practices in kindergarten classrooms during an integrated STEM+C curriculum. In particular, this study will focus on evidence of computational thinking found in student worksheets completed throughout the curriculum. The primary research question is: *How do student artifacts provide evidence of computational thinking during an integrated literacy, STEM, and computational thinking curriculum?*

Theoretical Framework

Pattern Recognition as Part of Computational Thinking

Computational thinking is a multifaceted construct as it comprises of several sub competencies such as problem decomposition, abstraction, debugging, and pattern recognition. In this study, we specifically focus on pattern recognition because of three key reasons.

First, pattern recognition is a common learning objective and reasonable to observe with young children, in our case four to five year olds. Previous research has examined several aspects of pattern recognition like pattern identification and completion with preschool children.[12] Pattern recognition also involves other abilities like extending and creating a pattern. Preschool students have capabilities to extend a pattern without much difficulty but have trouble creating a new one.[2] Other studies with pattern completion focus on the relationship between numeracy competency and proficiency with pattern completion tasks using numbers.[13]

Second, pattern recognition is one of the CT competencies shows overlap with cross cutting concepts identified in the *Next Generation Science Standards* (See Table 1).

Finally, in the context of computational thinking, pattern recognition can be observed in a low tech setting or contexts. Pattern recognition is also one of the more comprehensive CT competencies associated with other competencies like abstraction (e.g., a child can look for find similarities while abstracting patterns, themes across a set of objects).[14]

Through a synthesis of previous policy documents and research literature across K-12 levels defining various computational thinking competencies, we compiled a comprehensive list of definitions. The objectives could represent different levels of progression of a certain competency.

In this study, we specifically focus on pattern recognition as classroom teachers implement the *PictureSTEM* curriculum.

Table 1. Computational thinking competencies, definitions, and learning objectives

CT Competencies	**CT Connections to NGSS**	**INSPIRE Definitions**	**Learning Objectives**
Abstraction	*Cross-Cutting Concept:* Structure and function.	Identifying and utilizing the structure of concepts/main ideas	Identify the general make-up or underlying themes of a structure or process.
			Utilize an abstraction (the general make-up or underlying themes of a structure or process) to do a task.
Algorithms and Procedures		Following, identifying, using, and creating sequenced set of instructions (i.e., through selection, iteration and recursion)	Follow a series of ordered steps to solve a problem or achieve some end.
			Identify the sequence of steps to be taken in a specific order to solve a problem.
			Apply an ordered series of instructions to solve a similar problem the algorithm was designed for.
			Create an ordered series of instructions for solving a problem.
Automation		Assigning appropriate set of tasks to be done repetitively by computers	Assign appropriate set of tasks to be done repetitively by computers.
			Recognize different forms of automation.
Data Analysis	*Cross-Cutting Concept:* Patterns. Cause and effect.	Making sense of data by identifying trends	Describe patterns in data.
Data Collection		Gathering information pertinent to solve a problem	Identify relevant variables corresponding to a given problem
			Gather data to analyze relevant variables to answer a question.
Data Representation		Organizing and depicting data in appropriate ways to demonstrate relationships among data points via representations such as graphs, charts, words or images	Organize data in appropriate ways to demonstrate relationships among data points.
			Present data using suitable representations such as graphs, charts, words or images.

CT Competencies	CT Connections to NGSS	INSPIRE Definitions	Learning Objectives
Debugging/ Troubleshooting		Identifying and addressing problems that inhibit progress toward task completion	Identify problems that inhibit progress toward task completion.
			Address problems using skills such as testing, comparison, tracing, and logical thinking.
Parallelization		Simultaneously processing smaller tasks to more efficiently reach a goal	Develop processes that can simultaneously accomplish small, repetitive tasks efficiently reach a goal.
Pattern Recognition	*Cross-Cutting Concept:* Patterns	Observing patterns, trends and regularities in data (Google)	Identify a given pattern.
			Complete a missing pattern with colors and letters (pattern completion).
			Show abstraction by representing a color patter using letters (pattern abstraction).
			Create an original pattern.
Problem Decomposition	*Cross-Cutting Concept:* Structure and function	Breaking down data, processes or problems into smaller and more manageable components to solve a problem	Break down processes or problems into smaller and more manageable components to understand the components or issues.
Simulation	*Cross-Cutting Concept:* Systems and system models	Developing a model or a representation to imitate natural and artificial processes	Generate a model or representation to imitate a process.

Method

Participants

For this study, participants have been selected from one Kindergarten classroom taught by a female teacher in a rural school district in the Midwestern United States. The lessons were implemented in the fall of the school year. All students participated in the integrated STEM unit, however not all students attended all lessons. Two of the lessons included pair work. Eight pairs of students who attended all four target lessons were included in this sample, sixteen total students, including nine female and seven male students (See Table 2). All students names given in Table 2 are pseudonyms.

Table 2. Student demographics

	Partner A		**Partner B**	
Pair	**Name**	**Gender**	**Name**	**Gender**
1	Allyson	Female	Amy	Female
2	Brianna	Female	Bill	Male
3	Carl	Male	Cathy	Female
4	Darlene	Female	Denise	Female
5	Evan	Male	Erin	Female
6	Farrah	Female	Frank	Male
7	Gary	Male	Genna	Female
8	Hal	Male	Henry	Male

Context

PictureSTEM incorporates science, mathematics, engineering, technology, literacy, and computational thinking into three different lesson plans targeted at Kindergarten, first, and second grade students. The curriculum used in this study was the Kindergarten-focused lesson, *Designing Paper Baskets*. There are six main lessons as seen in Figure 1 in addition to an introductory lesson that presents the engineering design challenge. The unit is centered around the engineering problem presented by the two clients, Max and Lola. They are avid rock collectors and would like the students to design a basket made from common papers that they can share with their friends. The end goal is the plan for the basket so that others can make baskets that will allow them to carry wet or dry rocks. To solve this problem, students learn about the properties of paper and patterns to weave the baskets. Computational thinking is the focus of one STEM lesson (4B and is a major component of the connecting literacy lesson and the engineering design challenge.

Each lesson includes a book designed to connect a STEM+C (science, technology, engineering, mathematics, and computational thinking) lesson that highlights concepts needed to solve the engineering challenge in addition STEM+C lessons where students design solutions to the challenge. For the *Designing Paper Baskets* lesson, students focus on pattern recognition competencies (Lesson 4) as they design and test an engineering solution which is a basket to hold wet and dry rocks in this case.

	Lesson 1:	Lesson 2:	Lesson 3:	Lesson 4:	Lesson 5:	Lesson 6:
Literacy Connections	Book: If You Find a Rock Strategy: Identify beginning and ending sounds of words	Book: I Get Wet (Part 1) Strategy: Blend three letters in sound boxes that represent the phonemes of a word	Book: I Get Wet (Part 2) Strategy: Summarize text using interactive writing	Book: Pattern Fish Strategy: Identify rhyming words and patterns	Book: The Most Magnificent Thing Strategy: Making connections to the text	Book: Rocks, Jeans, and Busy Machines Strategy: Summarize narrative text with interactive sentence writing
STEM+C Connections	Identify properties of paper samples and sort using those properties.	Learn about properties of paper when wet and dry through the water drop test, wax and water test.	Test the strength of dry/wet paper with rocks.	Identify and create patterns, explore repeating and alternating patterns, identify weaving pattern for basket plan.	Choose papers and complete basket plan, work on debugging solution, build a model basket.	Test baskets with wet and dry rocks and communicate solution to clients.

Figure 1. *Designing Paper Baskets* lessons

Data

Three forms of data have been used for this study, the curriculum documents, student worksheets, and student prototypes. The curriculum documents are those published and used by the teachers to implement the curriculum. Students completed worksheets during each lesson and created a prototype of their basket design during Lesson 5B. Lesson objectives and artifacts used for analysis from each lesson can be seen in Table 3. The worksheets used for this study are found in Appendix A and the complete *PictureSTEM* curriculum can be found at http://picturestem.org/. Data has been collected in accordance with Purdue University IRB #1507016230.

Table 3. Focus areas of the integrated STEM+C curriculum

Lesson	Integrated STEM+C Focus Areas	Artifact
4A	*Literacy:* Discuss what makes some literature poetry. • Generate a rhyming and non-rhyming word for a given keyword. • Generate pairs of rhyming words. • Recognize rhyming words in the story. *Mathematics:* Generate the next item in a pattern through spoken words, written words, colors, and letters. Begin to work on abstraction of patterns by assigning letters to repeating patterns. *Computational Thinking:* Problem Decomposition – breaking down tasks into smaller, manageable parts, Pattern Recognition	Worksheet
4B	*Science:* A model can be used to illustrate how the shape of an object helps it function as needed to solve a given problem. *Engineering:* Investigate how the woven pattern changes the strength. *Mathematics:* Pattern Recognition (focus on identification and abstraction to letters) *Computational Thinking:* Pattern Recognition – explore how different patterns repeat and alternate in basket designs	Worksheet
5B	*Mathematics:* Patterns	Worksheet

Lesson	Integrated STEM+C Focus Areas	Artifact
5B	*Science:* A model can be used to illustrate how the shape of an object helps it function as needed to solve a given problem. *Engineering:* Develop a simple model based on evidence to represent a proposed tool. *Computational Thinking:* Debugging/Pattern Recognition – identifying errors in patterns	Prototype (Video)

Data Analysis

This study used two methods to answer the research question, artifact analysis and document analysis (as a subset of artifact analysis). The *PictureSTEM* curriculum was carefully examined using document analysis to identify prompts that helped demonstrate computational thinking competency of pattern recognition from the CT competency list in Table 1. Pattern recognition further includes other relevant competencies like pattern identification, abstraction and completion. Thus, learning objectives based on pattern recognition were framed in correspondence to each prompt (See Table 4) as included within the curriculum document.

Student artifacts, including the worksheets used during lessons and the prototype baskets built, were analyzed using artifact analysis and document analysis.[15] The results were compared for patterns in student responses within specific documents and across documents to explore student learning throughout the curriculum.

Results

Curriculum Analysis

The document analysis of the curriculum itself showed that the implementation of the *Designing Paper Baskets* curriculum was able to provide evidence corresponding to certain CT competencies like pattern recognition. The learning objectives in Table 4 show that the prompts provided in the *PictureSTEM* curriculum yield evidence for CT competencies as expected.

Student Artifact Analysis

As students completed a worksheet (Lesson 4A) to demonstrate their understanding of patterns by representation of patterns with letters and colors, we found that students were able to convert patterns in color into letters but had trouble with representation of complete patterns with repeatable units (Table 5).

A correctly written pattern will have a repeated pattern unit (for example the correct way to represent an AAB pattern is AABAAB). Thus, Table 5 shows that for problems 1 and 2 in Lesson 4A, most students identified the correct pattern units (AAB and ABC) but they wrote an incomplete pattern as the repetition was missing. The appropriate responses are AABAAB and ABCABC for question 4, "Use letters to describe patterns". Additionally, Farrah and Frank only wrote an individual unit for problem 1. Most pairs (6 of 8, or 75%) demonstrated incomplete patterns. They were able to identify the individual unit but not the repeatable unit for the patterns in problems 1 and 2 (in Lesson 4A worksheet).

Table 4: *PictureSTEM* curriculum prompts for CT-related learning objectives

Lesson	Prompt (from curriculum document)	CT-related Learning Objectives	Artifacts
4A	Have students complete problems 1-3 on the worksheet (after they read *Pattern Fish* with the teacher and explore patterns as they go through the book). Teacher asks: *Can you use letters to describe the patterns in problems 1 and 2?*	• Pattern completion: Complete a missing pattern with colors and letters. • Pattern abstraction: Show abstraction by representing a color patter using letters.	Worksheet
4B	Have students complete #1-3 on the BLM by labeling the patterns with letters (As and B s). Share out student ideas about Pattern#3 (AABAAB, over-over-under, over-over-under). Ask what they think would happen if the pattern didn't alternate between the rows (teacher shows model #4). Allow students to explore with patterns and create their own weaving pattern using either colors or letters to complete boxes for #5 on BLM.	• Pattern identification: Identify a pattern demonstrated in class and represent them with letters. • Students create their own weaving patterns.	Worksheet
5B	In pairs, have students decide the two options for their baskets and mark their choices on the BLM. First they should decide which paper they would like to use for their strips. Second they will need to decide which pattern they will use to make their basket.	• Students create a basket plan with their choice of paper and pattern. • Students justify their paper choices and basket patterns prior to designing their basket.	Worksheet
5B	Have pairs show their basket to the class and explain the following (prompt students as necessary): • Why they chose the papers they did? • How their basket meets Max and Lola's needs? • How they think their basket will perform on the wet and dry tests? • What patterns they chose and why?	• Students justify their paper choices and basket patterns after trying their basket plan with paper.	Prototype (Video)

Table 5. Representation of patterns with letters and colors (Lesson 4A)

Name	Color the next box (Q1/Q2)	Write the next letter (Q3)	Use letters to describe patterns (Q4)	Interpretation
Allyson	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Amy	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Bill	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Briana	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Carl	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Cathy	Green/yellow	B	AABB/ABC	Pattern 1 and 2 incomplete
Darlene	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Denise	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Erin	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Evan	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Farrah	Green/yellow	B	AAB/?	Pattern 1 and 2 incomplete
Frank	Green/yellow	B	AAB/?	Pattern 1 and 2 incomplete
Gary	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Genna	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Hal	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete
Henry	Green/yellow	B	AAB/ABC	Pattern 1 and 2 incomplete

In the following lesson, students represented patterns with letters as well as created their own patterns as they worked in pairs. Results from the Lesson 6B worksheet are shown in Table 6.

Students were asked to create a pattern on the worksheet in Lesson 4B. The artifact here showed that some students used old patterns that were already provided to them within the previous lessons while others created new patterns. Some students, like Cathy and Darlene, were unable to present a pattern at all. Others presented a pattern only horizontally but had trouble with vertical representation (For example, Allyson, Bill and Erin). Henry showed a new pattern vertically.

Given additional space, he may have created a horizontal pattern as well, however he does not repeat any pattern units horizontally and therefore does not create a horizontal pattern.

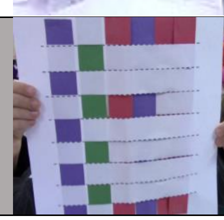
Table 6. Representation and creation of new patterns (Lesson 4B)

Name	**Use letters to show patterns (Q1/Q2/Q3/Q4)**	**Create your own pattern**	**Interpretation***
Allyson	ABAB/AABB/AABAAB/ABAB	ABBABB ABBABB	New, Horizontal
Amy	ABAB/AABB/AABAAB/ABAB	ABAABA BBABAB	Not Pattern
Bill	ABAB/AABB/AABAAB/ABAB	BBBAAB BBBAAB	New, Horizontal
Briana	ABAB/AABB/AABAAB/ABAB	ABABABB ABABAB	Old, Horizontal
Carl	ABAB/AABB/AABAAB/ABAB	ABBABB ABBABB	New, Horizontal
Cathy	ABAB/AABB/AABAAB/ABAB	AABAAB ABAABA	Not Pattern
Darlene	ABAB/AABB/AABAAB/ABAB	AAAABB BBBBBA	Not Pattern
Denise	ABAB/AABB/AABAAB/ABAB	AABAAB AABAAB	Old, Horizontal
Erin	ABAB/AABB/AABAAB/ABAB	BAABAA BAABAA	New, Horizontal
Evan	ABAB/AABB/AABAAB/ABAB	ABBABB ABBABB	New, Horizontal
Farrah	ABAB/AABB/AABAAB/ABAB	AABAAB AABAAB	Old, Horizontal
Frank	ABAB/AABB/AABAAB/ABAB	ABBABA ABABBA	Not Pattern
Gary	ABAB/AABB/AABAAB/ABAB	AABAAB AABAAB	Old, Horizontal
Genna	ABAB/AABB/AABAAB/ABAB	ABBABA BBAABB	Not Pattern
Hal	ABAB/AABB/AABAAB/ABAB	AABAAB AABAAB	Old, Horizontal
Henry	ABAB/AABB/AABAAB/ABAB	ABBBBA BAAAAB	New, Vertical

***** Old: Pattern already exists in worksheet.
New: Pattern does not exist but originally created by student.
Horizontal: Pattern repeats horizontally.
Vertical: Pattern repeats vertically.
Not: Not a pattern either horizontally or vertically.

As students started designing their basket plan, they used a worksheet to select a basket pattern. We also examined if the selected basket pattern matched with their actual basket prototype they created. Table 7 compares the students' initial plan and the prototype they created during Lesson 5B.

Table 7. Selection of a basket pattern compared to basket prototype

Name	**Selected basket pattern**	**Prototype**	**Image**
Allyson Amy	Designed own (BAABAA)	Horizontal ABAB pattern (waxed paper)	
Bill Briana	ABABAB	Horizontal ABAB pattern	
Carl Cathy	ABABAB ABABAB	First 3 rows showed a ABAB horizontal and vertical pattern. Next 3 rows only showed horizontal pattern	
Darlene Denise	ABABAB	ABAB pattern horizontal and vertical for the first 5 rows then not vertical pattern.	
Erin Evan	AABAAB	ABAB pattern horizontal and vertical	
Farrah Frank	ABABAB	BABABA (wax paper)	
Gary Genna	ABABAB	ABAB with alternating first 2 rows. ABBBBA for the remaining rows.	
Hal	ABABAB		

Name	Selected basket pattern	Prototype	Image
Henry		Made it with copy paper. Did ABAB pattern and then changed it to BABA.	

All pairs except Allyson and Amy marked ABAB as their pattern of choice on the worksheet. The pairs used a variety of papers. One pair (Erin-Evan) built a basket with the ABAB pattern (however they chose the AABAAB pattern on the worksheet). Two groups (Carl-Cathy and Darlene-Denise) started with a horizontal and vertical ABAB pattern but they showed no vertical pattern. Lastly, Farrah and Frank selected the ABAB pattern on worksheet but this did not match with their basket design.

Discussion

As listed in Table 1, our list of learning objectives corresponding to pattern recognition, include pattern identification, pattern completion, pattern abstraction and pattern creation. Thus, as intended by the *PictureSTEM* curriculum (See Table 4), the analysis of student work and artifacts from the lesson were able to yield student evidence and related difficulties in terms of these objectives.

From triangulation across worksheets, we find that students demonstrate difficulty with representing computational thinking competencies like pattern recognition like writing a pattern with repeatable units (See Table 5 and 6). A reason for this observation could be classroom instruction which showed that teachers at times presented a pattern with just one repeatable unit. Thus this could have translated to the students in how they presented patterns.

A pertinent issue, similar to assertions in previous literature, was creating a complete original pattern.[2] Students were able to show a horizontal pattern but often had difficulty with vertical pattern (see Table 6). This difficulty was also observed for their basket prototypes as shown in Table 7. Here we also recognize that pattern abstraction as another problematic area because students' basket prototype mismatches with their selected design.

Conclusions

This curriculum and the artifacts associated with it provide evidence of computational thinking by Kindergarten students during the *PictureSTEM* curriculum *Designing Paper Baskets*. Computational thinking has many components. In this study, pattern recognition was the main focus. Pattern recognition in a single direction seems to be a developmentally appropriate skill for these Kindergarten students, however pattern recognition in two directions, both horizontally and vertically, was not commonly seen. This is another area where more direct teacher intervention might be needed to better scaffold students' pattern making abilities.

Limitations

This study is limited to one classroom of Kindergarten students. This is the first implementation of this engineering curriculum for the teacher, so both students and teacher were learning how engineering looks in a Kindergarten classroom. Higher fidelity of implementation and comfort with engineering and computational thinking concepts and practices could alter students' understanding and performance. The artifacts analyzed are also highly proscriptive; they may not show complete or accurate evidence of students' understanding of targeted computational thinking skills and practices.

Future work

This study is a first look at how the *PictureSTEM* curriculum for Kindergarten students, *Designing Paper Baskets*, encourages and computational thinking. Specifically, this study explores how the artifacts produced by students during the lessons show evidence of computational thinking for Kindergarten students. Future work includes expanding this pilot study to multiple classrooms and multiple grade levels. Computational thinking and engineering design have many overlapping practices; future work also includes exploring whether students who show advanced understanding of computational thinking also show advanced implementation of engineering practices.

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Appendix A: Student worksheets

Lesson 4A

Pattern Fish – Rhyme Assessment

Name: ____

Directions: Say, "Tell me a word that rhymes with [use each word in the list below]." Record the student's responses on the lines provided. Nonsense words are okay.

Test Items	Student Responses
1. black	____________________
2. pop	____________________
3. dot	____________________
4. kite	____________________
5. red	____________________
6. spot	____________________
7. hook	____________________
8. ball	____________________

Total Rhymes Correct ____________________

Lesson 4A Pattern Fish - Patterns

Name______________________________________

Directions: Color the next box in the pattern.

1.	yellow	yellow	green	yellow	yellow	green	yellow	yellow	?

2.	red	green	yellow	red	green	yellow	red	green	?

Directions: Write the next letter in the pattern.

3.	A	B	B	A	B	B	A	B	

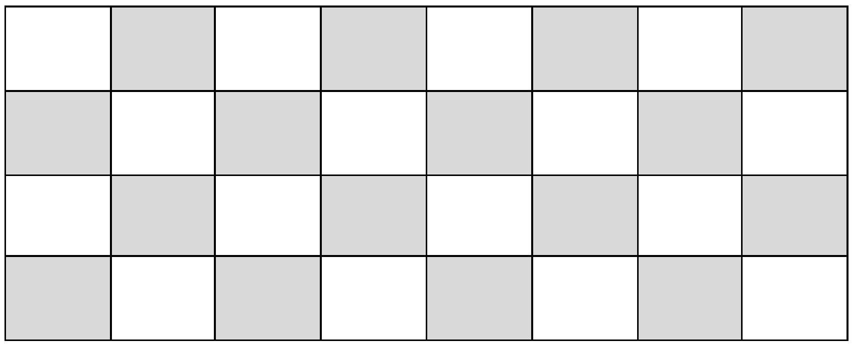
4. Use letters to describe the patterns in problems 1 and 2.

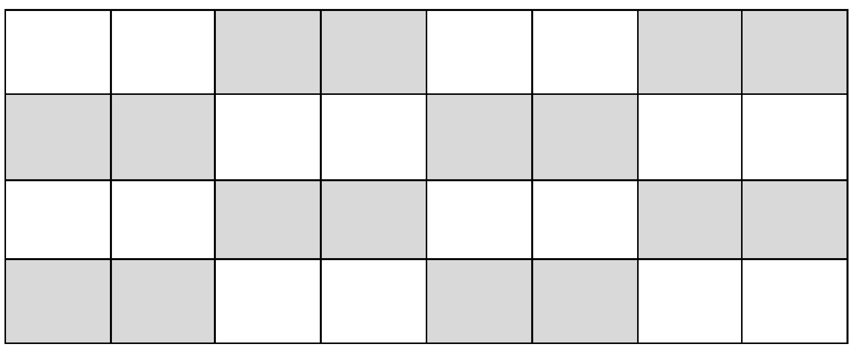
Lesson 4B

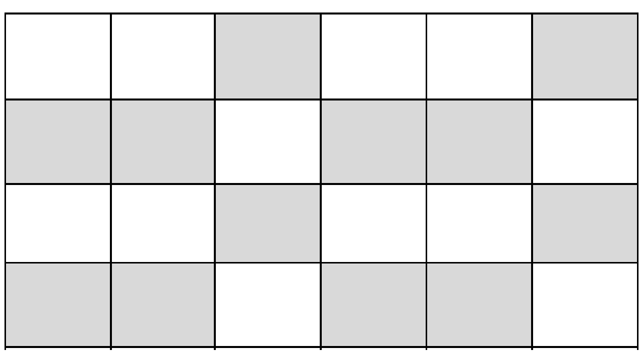
Weaving Patterns

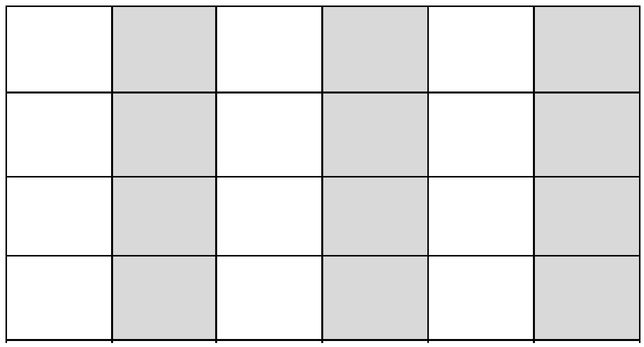
Name_______________________________________

Use letters to show the pattern that you see in the boxes below.

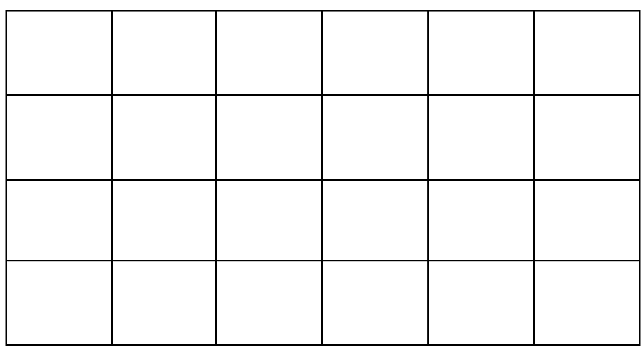
1. 

2. 

3. 

4. 

Create your own Weaving Pattern

5. 

Lesson 5B

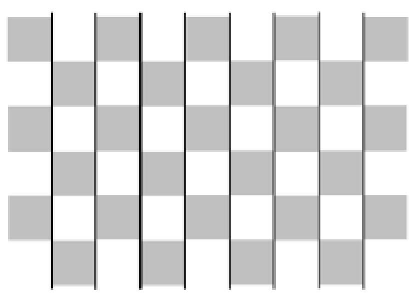
Basket Design Plan

Name____

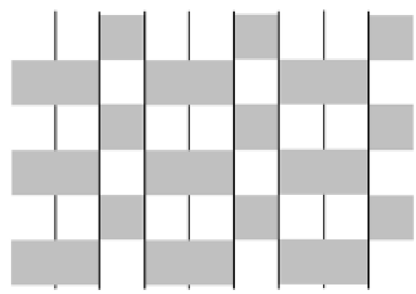
1. The basket strips I will use are:
   - ☐ 1. Construction paper
   - ☐ 2. Copy paper
   - ☐ 3. Waxed paper
   - ☐ 4. Tissue paper
   - ☐ 5. Paper towel

2. Circle the pattern you will use to make your basket. You may design your own.

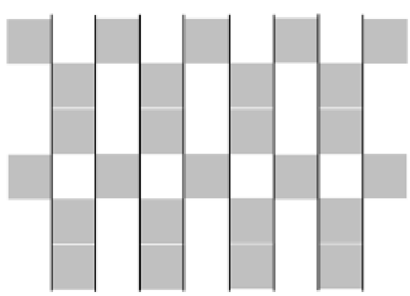
A.



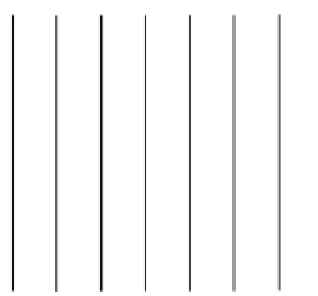
B.



C.



D.



Lesson 6B

Final Basket Design Plan

Name____

Test	Do you think it will hold 30 rocks? (circle one)	# of rocks basket held	Describe how the basket looks after testing. (circle one)
1. Dry Rocks	Yes No		There was no change. Some tears. It broke.
2. Wet Rocks	Yes No		There was no change. Some tears. It broke.

3. Should Max and Lola use your basket design? Yes No

4. The basket strips Max and Lola should use are:

- ☐ A. Construction paper
- ☐ B. Copy paper
- ☐ C. Waxed paper
- ☐ D. Tissue paper
- ☐ E. Paper towel

5. Circle the pattern Max and Lola should use for their basket instructions.