Algorithms: The Bridge for Young Minds to Understand Artificial Intelligence

by Kara Anne Boneillo 2014 CTI Fellow
Reedy Creek Elementary

This curriculum unit is recommended for:
Fourth and/or Fifth Grade, Math/Science/Writing/Reading

Keywords: algorithms, algorithmic thinking, analysis, argumentation, Artificial Intelligence, causality, claims, coding, data, DNA, equations, evidence, forethought, genetics, inferences, looking ahead, processes, relationships, retrospect, and systems

Teaching Standards: See **Appendix 1** for teaching standards addressed in this unit.

Synopsis: This curriculum unit seeks to teach students to think independently, as they examine the relationships between and within systems. In this unit, each activity will seek to integrate mathematics and writing, in order for students to develop strong Twenty-First Century skills. This unit will incorporate the scientific method, systems and inferences. Students will understand how to look ahead and break a complex activity into a set of simple steps, using algorithmic thinking. By designing algorithms, to simple daily tasks, students will see how mechanical daily tasks are, which will allow them to make connections about the importance of each step in any process. Students will develop an understanding of the fundamental difference between weak Artificial Intelligence and strong Artificial Intelligence throughout the unit. Students will reflect on activities to reach the realization that daily actions can be simplified into a series of steps; it's the nervous system, and the ability to truly think, that is so complex that it is still beyond our current understanding. This is the essential problem, computer scientist and neuroscientist face, with the task of recreating a computerized version of a human brain. By the end of this unit, students will understand and utilize looking ahead and algorithmic thinking.

I plan to teach this unit during the coming year in to 55 students in fourth grade math, science, and writing.

Rationale

Artificial Intelligence (AI) functions on the belief that any physical process, including the ones governing human cognition can be simulated and possibly replicated, by dissecting the process at hand into a straightforward series of steps, or in other words an algorithm. The foundation of any educational program, and our daily task, as teachers, is to educate our students by modeling different strategies, or series of steps, that they can repeat over and over, to hone their thinking, to learn and retain new information. This curriculum unit (CU) will build upon this philosophy through the use of the different activities that can be integrated into any class and differentiated in order to teach students how to see any lesson, concept, or task for what it is- a series of steps that must be followed in order to achieve the desired end result, or product.

Algorithmic thinking is important for all students in all grade levels across all disciplines. In order for students to use the foundational skills we teach them on a daily basis, they must be able to analyze their problem at hand, or task, independently, and create an ordered list of actionable steps. This CU will guide students through the history and the subfields of AI at a developmentally appropriate level and pace to build this essential foundational skill that can be used across the board, no matter the subject. As we progress through this CU, students will be introduced to the two distinct branches of AI, weak AI and Strong AI, and discover how they are different. Students will be exposed to the fundamental beginnings of AI including the noteworthy scientists and their contributions, such as the Turing's 'imitation game' and IBM's Watson and Deep Blue. They will make connections to AI's past and present as they examine current weak AI artifacts, or gadgets, such as the Google self driving car and current robotics equipment. They will learn how artifacts are created and operated by applying their newly acquired knowledge as they try to code, at a basic level, on select educational websites. As a class, we will discuss the implications of past AI on current technology and discuss how, and if, it will be possible to transition into stronger AI through our nonfiction writing, which will facilitate the application of the Common Core standards. The writing assignments within this unit will allow them relevant practice putting their thoughts, pertaining to a selected topic, onto paper and use those thoughts to guide group discussions.

Introduction

"How complex is the world really?" is an essential question for retrospection for any scientist. Humans, other animals, and machinery operate alongside Mother Nature in what appears to be a dynamic dance, yet it all is very mechanical when observed and dissected. Life, Earth, and Physical scientists' have debated for years on end over the question of the Earths' and society's' complex nature. Computer scientists focus on the vision and simulation of the human brain rather than its complexity. Instead of debating and defining the complexity that is intelligence they seek to automate it. Bhatt (2013) stated "Artificial Intelligence (AI), a term that in its broadest sense would indicate the ability of an artifact to perform the same kinds of functions that characterize human thought processes."[1]

We are living in a digital age; everything we do is tied to an electronic device at almost every point of our daily lives. The average two year old can operate a cell phone or iPad without assistance. Tsalapatas et al. (2012) declared "There is a growing demand for employees in STEM occupations who can effectively deal with emerging problems using analytical thinking skills, technology, mathematics, and science"[2]. They referred to the lack of growth within elementary classrooms in terms of interactive and engaging experiences with Science, Technology, Engineering, and Math (STEM) concepts and their application to the real world. Before the Twenty First Century, we desired to cultivate a literate generation of students that could read, write, and perform basic arithmetic via paper. According to Davidson (2012) "A student today needs a fourth R: Reading, 'riting, 'rithmetic and 'rithms, as in algorithms, or basic computational skills".[3] Davidson compared the necessity of the ability to read, write, and compute during the Industrial Era to the current need for students, and people in general, to understanding algorithms in this digital age we live in. Bass (2003) stated "An algorithm consists of a precisely specified sequence of steps that will lead to a complete solution for a certain class of computational problems".[4] In essence, a step by step process that yields a desired end result.

Tsalapatas et al. (2012) acknowledged that we live in a 'Creative Society' where it is important to perform problem-solving using logical and critical thinking.[5] Resnick highlighted the importance of imagination, creativity, "playing", sharing, and reflecting in kindergarten, which disappears during the lower grades and is nonexistent by the upper grades. She stated that she believed that digital technologies, if properly designed and supported could extend the kindergarten approach, so that learners of all ages can continue to learn in the kindergarten style- and, in the process, continue to develop as creative thinkers."[6]

Digital literacy requires a knowledge and command of algorithms and algorithmic thinking in order to operate, much less create, computer programs and software efficiently. A strong foundation of reading, writing, and arithmetic is still a crucial necessity. Directions must be clear and concise for a person to follow, much less a computer. My students have difficulty researching on web servers because they put an entire question into the search bar, rather than key words because they do understand the distinction and how the search engine operates. Students have the misconception that the computer is in fact intelligent and can therefore answer their questions directly. Futschek (2006) declared it best "Algorithmic thinking is somehow a pool of abilities that are connected to constructing and understanding algorithms: the ability to analyze given problems, the ability to specify a problem precisely, the ability to find the basic actions that are adequate to the given problem, the ability to construct a correct algorithm to a given problem using the basic actions, the ability to think about all possible special and normal cases of a problem , and the ability to improve the efficiency of an algorithm."[7]

Today students need to use precise language and understand domain-specific vocabulary in order to produce clear and coherent artifacts and ideas as required by the Common Core standards. Beyond computer applications, there is a need to use algorithmic thinking in all aspects of education. The meaning of a word changes depending on the way it is used in conjunction with other words. In essence, writing is an algorithm. The use of idioms and figurative language often confuses elementary students because they are still developing their vocabulary. Certain sentences require the use of specific prepositions, or verbs, in order for them to make sense in context. For example, I had a typo that escaped my edit check on a study guide I distributed to my students during our end of unit wrap up for the Earth, Sun, and Moon unit I taught this year. On the study guide I asked my students to create a diagram of the earth rotating on its axis as it revolved around the sun and write the following sentence underneath it, filling in the blanks correctly: Sunrise and sunset are caused by the (blank) of the earth in its (blank). I had wanted my students to say rotation first followed by axis but since I used the word "in" instead of "on" it changed the meaning of the whole sentence, therefore I had some of my students reply with tilt first and rotation second or different answers. A majority of my students either did not pick up on it, or did but knew what I meant, and gave me the answers I expected. The students who provided tilt and rotations have mastered the skill of how to use grammar to select an answer choice. However, a large portion of my students struggle with how specific grammar choices change the context and can help them eliminate answers when choosing from a set of multiple choice options.

Grammatical errors, or problems with comprehension of words on a page, affect a student's ability to understand concepts in reading and the social sciences but simple errors like my grammatical error are similar to math errors I see in my students work all the time. They make simple computational missteps that they do not catch in their computation, usually because they do not know how to "check" their work because they lack an understanding of the strategies and concepts we work with. Students try to take shortcuts, or use traditional algorithms their parents show them, which prevents the deeper understanding I try to cultivate in my classroom. Learning what algorithms are and how to create them is a worthwhile activity to facilitate the development of a solid number sense. The "new math" seeks to teach appropriate base ten strategies to students to facilitate a deeper understanding of how numbers change with different operations so they can perform computation with the traditional algorithms effectively in the future. If students and parents understood what an algorithm is and how important the skill of algorithm thinking is, they would appreciate the Common Core and our Investigations math program.

Futschek (2006) proposed that the most reasonable and convenient approach to teach algorithmic thinking is to solve a lot of problems that are simple in nature and to use tools that visualize algorithms.[8] In his paper on the significance of algorithms, Bass provided a detailed account of the important qualities an algorithm must have: accuracy, generality, and efficiency. In this CU we will focus on the following essential questions: What is Artificial Intelligence and why does the world, especially elementary students, need to know about it? How can students understand the importance of current technology and the strides it took to get to where we are and where we still want, and need, to go? How does AI affect our daily life and how will the future findings of the discipline shape our culture? What is an algorithm and how does algorithm affect my ability to grow in my academic endeavors? I want my students to create their own questions like mine that will get them to open their minds and start to analyze the world of possibilities involved in artificial intelligence. I hope and expect some of my students to become interested in robotics and STEM fields and choose to attend a middle school with a heavy STEM focus, so I want them to really understand what artificial intelligence is and the importance of understanding it.

Background

School Specific

This CU is intended for two fourth grade academically gifted classes, that are part of a fourth grade TD/ESL cluster located at a Pre-Kindergarten through fifth grade elementary school in the Charlotte Mecklenburg school district. My school is located on the outskirts of the East side of the city of Charlotte, North Carolina where suburbia meets rural farmland. My school is very diverse, which has allowed the opportunity to create clusters within each grade level, to adequately support all of our learners. The students I teach are part of the Talent Development (TD) and English as a Second Language Learners (ESL) programs. I team teach two classes with a partner. I teach Math and Science to both classes, while my partner teaches Social Studies and Reading to both classes. I also teach writing to my homeroom group.

As part of Charlotte Mecklenburg Schools, we follow the common core standards through the use of district pacing guides. Though I teach the talent development cluster, we have a very small amount of certified gifted students, usually three or four a year. TD is a new term that replaces the older term, academically gifted and talented (AIG). At the elementary level, students qualify in second grade as TD after different problem solving and visual tests that judge their creativity and perception. A majority of our cluster is made up of TD catalyst students. These are students who demonstrate a love of learning, and when pushed, can excel to meet high expectations but are currently performing the same as the rest of their peers on testing due to a lack of adequate study skills and thought processes. TD catalyst students are identified by their classroom teachers through informal observations as well as formal testing such as common assessments, formatives, and end of grade testing. Some of my students are performing below grade level but were selected to be in the TD/ESL cluster because they show great potential and would benefit from an interactive rigorous class. This requires me to differentiate my lessons to allow for partner work, cooperative learning teams, and small group instruction to facilitate an environment that can allow students to progress and develop their natural abilities. My goal every year is not only to have my students show growth and achieve proficiency, but to be able to explain their work and thoughts out loud as well as on paper. I push my students hard so that they work hard with the intention that the next grade will be easier because they will have a solid set of work and study skills.

My school is ranked 68th out of 100 elementary schools in the Charlotte Mecklenburg District. My schools overall composite score is 46% . A school composite score is created by averaging the end of grades tests for math, reading and science in grades three through five. We are meeting adequate yearly progress overall, though we fell short on some individual goals this past year. Our school has shown strong gains in math, especially fourth grade, but is struggling in reading and science proficiencies. The standards and testing have changed in the past two years and our faculty is working hard to adjust and differentiate instruction to achieve continued growth. We have roughly 800 students, pre-kindergarten through fifth grade. The demographics of my school are: 57% African American, 24% Hispanic, and 13% white. The remaining portion of our students are Asian, Native American, or multi-racial. Currently, 66% of the students that attend my school are considered economically disadvantaged. Our parents love and support their children academically to the best of their ability. School has changed drastically, just as society has, since my students' parents were in school. This makes it hard for parents to support their children at home academically because the content and way we teach is new and different. A majority of our parents work odd hours and days, so our students have a vast array of afterschool situations. This makes it hard for parents to be involved in the school community as well. Our PTO is therefore very small, but also very supportive. As a school we are trying to engage the community and organizations to step up and be involved in our school to help balance these aspects.

My school has gone through the traditional shifts all Charlotte Mecklenburg schools have with the new standards, the new evaluation systems, and the implementation of new rules and regulations that come with each year, but we have also gone through our own shifts. We have had growth in the number of students in some grades while other grades have decreased. A large population of our students' parents, in the upper grades, while content and happy with our procedures and techniques at our school, are worried about the middle school their children are zoned to go to. We often see a fluctuation in our numbers throughout the year as parents leave for "better" zones. This has caused some movement in our teachers. I used to be fifth grade and have now moved to fourth grade. While we dislike seeing our numbers dip so low that we lose classrooms, it has allowed for some great opportunities. I can add rigor and relevance to the fourth grade curriculum and help prepare fourth grade students for fifth grade, especially in science. Science has unfortunately taken a backseat for the lower grades, in order to meet state and district mandates. My school is focused on upgrading technology to raise scores and support students acquiring digital literacy. This will make implementing this unit easier than if I were at another school that has not prioritized technology. We have a computer lab that is open every morning for the first hour and a half of the day, as well as twenty iPads per grade level and a Chrome book cart.

I personally use multiple technology resources to stay in touch with the parents of my students. Our students come from families where all the adults in the home work so staying in touch electronically is easy and efficient for the parents and myself. I send pictures and comments electronically through the Remind App and post everything to my Weebly.com page. I utilize Class Dojo for behavior modification and rewards. In this day and age students are focused on fun and it can be hard to get them to stay on task and put forth their best effort. I utilize any technological device in the classroom that I can in order to keep them interested and extend their learning. I have high expectations for my students and offer a rigorous curriculum. This CU will help to strengthen the engagement of my students, while maintaining the high level of rigor and relevance I try to maintain.

Content

Bass (2003) stated “An algorithm consists of a precisely specified sequence of steps that will lead to a complete solution for a certain class of computational problems.” Any series of steps where words, symbols, numbers and signs can be combined together to guide a process to an end result can be referred to as an algorithm. For example, Google uses an algorithm when you search for a key word. It finds all the pages that contain the word and then ranks the pages based on the statistical relevance of the other words on the page, as well as the links to and from other pages. Another vastly different way of algorithmic thinking is reading. A reader must follow a series of steps in order to read. You must pick up a book, look at the top of the page, and your eyes must travel from left to right. A capital letter tells you that you are starting a new sentence, or have encountered a proper noun. A comma tells you to pause briefly while a period tells you that you have come to the end of a statement. A question mark asks you to pause and think to seek information.

In this CU, I will focus on the area of Artificial Intelligence, whose goal is to algorithmically describe various facets of intelligence. Russell and Norvig (2010) summarize the goal of A.I. research as follows: “For thousands of years, we have tried to understand how we think; that is, how a mere handful of matter can perceive, understand, predict, and manipulate a world far larger and more complicated than itself. The field of artificial intelligence, or Al, goes further still: it attempts not just to understand but also to build intelligent entities”.[9] Digging a little deeper into the field of Artificial Intelligence, we can further define the quest of the field: creating an electronic facsimile of the human brain. In essence, AI seeks to automate the ability to think. Russell and Norvig further defined AI as a quest for the best agent program on a given architecture. They stated that there are four different categories of AI: thinking humanely, thinking rationally, acting humanly, and acting rationally. The four approaches have a correlation with the fields of psychology, sociology, mathematics, and engineering.

Currently a majority of the AI subfields focus on the performance aspect of AI, referred to as 'acting rationally' by Russell and Norvig. A majority of the subfields of AI work with gadgets and programming that imitate the brain's capabilities, rather than replicating the brain. Therefore artifacts created to date, can only accomplish one type of task. There is a large gap that stands between what current artifacts of AI can do when compared against a human. This is where two lines of thought sprouted: weak AI versus strong AI. Russell and Norvig clarified "The assertion that machines could act as if they were intelligent is called the weak AI hypothesis by philosophers, and the assertion that machines that do so are actually thinking (not just simulating thinking) is called the strong AI hypothesis."[10]

The concept of thinking is complex and multidimensional which makes it hard to recreate and function electronically independently of a human. Alan Turing, a leader in the field, famously posed a question that defines the current quest of strong AI. Turing asked "Can a Machine Think?"[11]. Turing discussed in his proposition that the basis of his question was nonspecific because one would have to define what a machine is and what exactly does "thinking" consists of which would take his straightforward question into a different realm. To answer his own question he restructured his question into a scenario he called the "imitation game", which is now referred to as the Turing Test. In layman's terms, a person is tasked with trying to tell apart a man from a computer, while only carrying on a conversation over a text-only channel. Turing believed a computer could be considered to be intelligent if after responding during an open dialogue of conversation, in natural language of the evaluator, through a computer screen from separate rooms, if said evaluator was unable to distinguish the human from the computer.

Turing and his test are essential foundations in the field of AI because he dissects the possibility of the perception of a computer as a human from different definitional components. Searle sought to refute followers of Turing and strong AI is his most famous publication the "Chinese Room Argument" published in 1991. Both articles, Turing and Searle's, are worthy for further reading, but I want to focus on some proposed definitions Searle proposed in a different article. Searle (1980) distinguished that "According to weak AI, the principal value of the computer in the study of the mind is that it gives us a very powerful tool. It enables us to formulate and test hypotheses in a more rigorous and precise fashion." He went on to distinguish, and deny the validity, of what he referred to as strong AI "According to strong AI, the computer is not merely a tool in the study of the mind; rather, the appropriately programmed computer really is the mind".[12]

Russell and Norvig stated "Al currently encompasses a huge variety of subfields, ranging from the general (learning and perception) to the specific, such as playing chess, proving mathematical theorems, writing poetry, driving a car on a crowded street, and diagnosing diseases. AI is relevant to any intellectual task; it is truly a universal field."[13]The mention of the work "weak" to describe AI can be misleading. AI, weak or strong, is not simple or basic but rather mechanical. Each subfield of AI has made great strides in producing relevant technology and advancements. IBM has provided Watson and Deep Blue which are computer programs that have beaten humans at games. Watson is an example of cognitive computing. It competed on Jeopardy and won using speech recognition software coupled with statistical language processing that allowed him to pick the best probable answer from a database created over time for this purpose. A key component in Watson's success was the use of machine learning algorithms. Machine learning is the ability of a digital machine, specifically a computer, to improve its performance towards accomplishing a task by using knowledge obtained while performing said task. Deep Blue was a computer program that used look ahead to determine the best move in a game of Chess. It analyzed the consequences of individual moves (by analyzing counter-moves and counter-counter-moves and so on) systematically and was the first program to defeat a human grandmaster in the game of Chess. Both programs constitute an algorithm composed of mechanical steps that have pioneered the subfields of game playing and machine learning which is the focus of my CU. AI is a heavy topic, as is any science for that matter. I recommend reading the different articles on the recommended reading list to further acquaint yourself with these topics as they pertain to the pieces of the CU you want to replicate in your own classroom.

Teaching Strategies

Curriculum Strategies

Common Core and our current math program adoptions, like Investigations and Marilyn Burns "Do the Math", ask students, and adults, to think about the broad picture and make connections between concepts, not specific facts, using visuals and explanations. It is not about memorizing, but rather analyzing and concluding. The "new math" requires students to think about what they know, information stored in their memory, and research things that are similar, to compare and contrast, and to make statements that can be tested. This is how students learn to problem-solve correctly. In this CU, I will focus heavily on problem solving methods and best practices that we use in our Math program.

Our TD program has the central themes of patterns, generalizations, and systems which mirror the core objectives of this unit's topic of Artificial Intelligence. Any day to day situation requires the brain to process, quickly, through a mental flow chart to pick the safest or the most positive outcome based on prior direct or indirect experience. Flow charts and maps will be utilized throughout my instruction this year. Levesque 2012 stated it best when she said, "This skill isn't about knowing a particular coding language: it's about understanding how to take something you want to happen and think through all of the processes, decision trees, edge cases and exceptions necessary to make it happen."[14] In this CU, my lessons will use the concept of flow charts, decision trees, and pictorial models to diagram scenarios, options, and mathematical computations in the activities we do as we look for regularity as we solve equations and story problems. Students will use the best practices of mathematics in each activity.

Russell (2000*)* stated it best when she said "Teaching for both skill and understanding is crucial—these are learned together, not separately. But teaching in a way that helps students develop both mathematical understanding and efficient procedures is complex. It requires that teachers understand the basic mathematical ideas that underlie computational fluency, use tasks in which students develop these ideas, and recognize opportunities in students' work to focus on these ideas."[15] I differentiate my lessons to meet the needs of my students through the use of the workshop model. I teach mini lessons to introduce or review concepts. I model math problems using an "interactive read aloud" approach where I highlight my thinking to solve a problem step by step. I partner my students to complete workshop rather than make them work independently during our math block. I utilize morning work and homework as time for independent practice. During centers, my students rotate while I am able to pull groups differentiated by level and skill. The Investigations math program promotes decomposing equations and word problems by using place value and facts you know to achieve an end result without following the traditional, more formal steps, of traditional algorithms, by memorization without understanding. I highly recommend this program as a solid foundation for any teacher to promote and foster number sense in their classroom.

Our current science program, the North Carolina Essential Science Standards, is based heavily on argumentation, using claims and evidence. There will be essential guiding questions that students address over and over, adding to and taking away, as they build their framework of what Artificial Intelligence is and how it affects their lives. I am an avid user of Paige Keeley's formative assessment strategies and probes, and utilize the hundred plus strategies she has produced between all of her books, throughout each unit I teach. I was inspired from reading her books to take the essential questions for a unit and have my students use them as a checkpoint before, during, and after each unit instead of a KWL chart so they can see the progression of their learning in the depth and length of their responses.

Classroom Strategies

Centers

My students spend a great deal of time learning from their classmates in partnerships and groups. Instead of watching a video, playing a game, or reading from the textbook or a passage as a whole group or working on a worksheet independently, my students do almost everything together in short time frames. My students rotate, or rather revolve as they tell me (since we learned about the Earth, Sun and Moon), through the same centers but the activities they do or the scaffolding that is there is differentiated to meet their level. I utilize technology, games, and computer programs that give immediate feedback rather than worksheets. While they are working, I am pulling a group or leading a lab, so

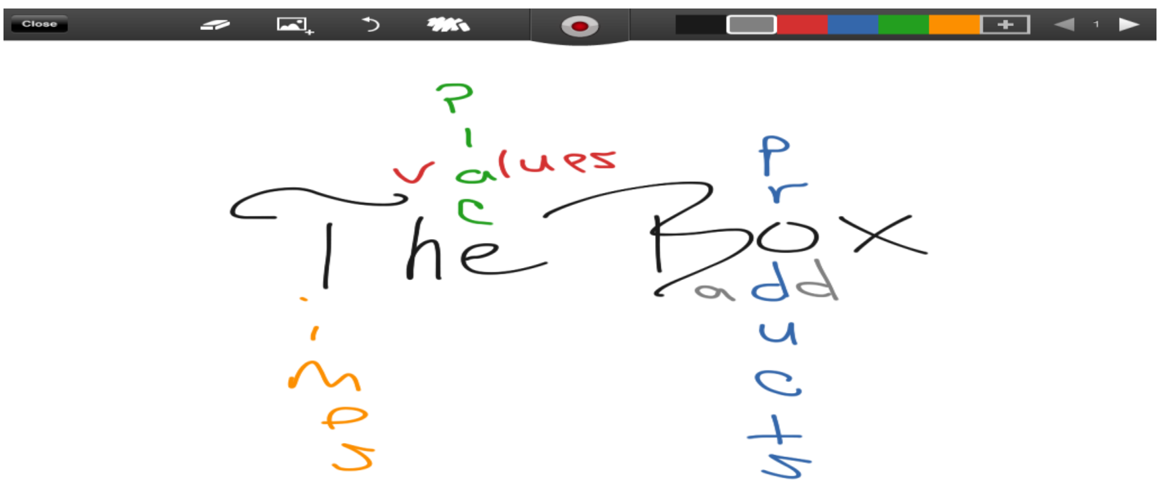
I want them to have the answers readily available. If they are completing a worksheet, such as Math Stars or Math Olympiad, then there is an answer key available in a folder at that center.

Anchor Charts

I have not been teaching exceptionally long but the start of my career, in 2007, often seems like forever ago. As a new teacher I was lucky to have technology readily available. It was easy to take my Promethean board and access to a class set of computers and a library of educational programs for granted. I had an elaborate webpage with all these resources, blogs, homework help message board, and links to interactive practice. I had taped some generic posters up that provided awesome definitions and examples for students to look at, yet a large portion of my students never looked at any of it. When I shifted from middle school to elementary school I learned about the importance of anchor charts to help my students learn. The most important aspect is creating the anchor charts with the class. It does not need to be fancy or picture worthy, though I take pictures of everything, to post to the website that still few check out.

Wordle Art-Def

I have grown in how I create my anchor charts and the different strategies I demonstrate on them. My students love what I call wordles for short. I was inspired to create a definition for every major concept or vocabulary word that utilize the concepts of Scrabble and the real Wordle (which is a bunch of connected words that make graffiti like poster or shape of the concept they refer to based off of how many times the word is used). I read a lot of research on how different learners acquire and hold on to new information and using the body along with color were popular themes. I had seen some different charts and posters on Pinterest and I decided to run with it. An example is provided below.



Interactive Notebooking

Pinterest and Google are covered in images and electronic directions for how to create and keep a interactive notebook. There are different "styles" and rules, such as the left and right side pages, but for me the rules are simple. Everything we do, papers, tests, warm ups, ticket out the doors, belong taped, stapled, or glued in the corresponding notebook in an organized fashion. I tried following the rules that are out there but learned quickly you have to do what works for you and your students. I love color and have found research that supports the use of color in studying so I let my students go crazy with color in their notebooks especially for math. We use a different color for each step, especially in our multiplication strategies like the box and break apart. I tell my students that when they look back in their notes they should be able to walk themselves through another example by just looking at their work. We try to keep the words limited for math and the examples heavy. My students like to experiment with how many papers they can fit on pages by folding them in different ways. I minimize the size of everything for two reasons: so it fits on the page and to save copies.

Thinking maps

As we learn about the different subfields of AI over the course of this CU I will require my students to create a thinking map of their choice or a simple chart that lists the subfield as the concept, key vocabulary, real world applications, and jobs in the field. It is important that my students link each activity with the application in the real world and the relevance to their daily lives and future aspirations. Thinking maps are versatile tools within the classroom learning environment that keep allows students to see the patterns in the material they are introduced to. They help students to find and create organization within the material they read, their notes, and help them draft their ideas throughout the writing process. I have (blank) examples of each thinking map suspended to the top of my board with magnetic tape. I love my white board because it has this retro light rod that runs the entire length of my board with a magnetic outer shell that makes it useful to hand anchor charts and other goodies as my wall space is always at a premium. When we are using a specific thinking map I will grab it down and make it the focus of my whiteboard and provide my students with a blank copy to refer back to, or trace. At the end of a unit I like for my students to think about the important concepts have learned, maybe a specific essential question, and reiterate it using a commix strip. This allows them to take their thinking maps and use creativity to pull together the overall concept of the unit while providing an outlet to demonstrate learning.

TAG

Students will be required to TAG their essential questions and journal entries. TAG means to turn around the question by making it a statement that serves as part of the first sentence of their response, answer the question, and provide details. I tell my student they need to give at least three details and they remember that because TAG has three letters.

Students are allowed to count their equations and diagrams, which they attach or put below their paragraphs, as part of their details but they must refer to them in the writing. Anytime my students have science questions, whether it be in their textbook or after a reading passage, I require them to TAG. The main purpose is for them to be able to use their answers later without having to refer to the original question. If they TAG accurately the question is within their first sentence. It keeps their notebooks organized, instead of a list of question, answer, question, answer. It also functions as a writing tool to anchor their writing to the topic.

3-2-1

Students will be required to use a 3-2-1 for note taking, especially during videos. A 3-2-1 requires students to write three new facts they learned, two interesting tidbits, or wow moments, and one question they still have. This is a favorite form of note taking for my students because it allows them freedom of expression and control over their learning while still holding them accountable and providing structure. I cannot rave enough about this simple strategy I learned at a workshop a couple years ago. My students use this strategy specifically any time they observe, read, or interact during an activity where I do not have a defined set of questions for them to answer. Often during videos they draw a line of learning underneath their 3-2-1 and add diagrams and additional facts.

Activities

Understanding Artificial Intelligence

Students will acquire the necessary background knowledge of the concept of Artificial Intelligence through the use of videos. During the videos, students will complete 3-2-1's which they will use to lead their group discussion after each video. The questions they create will be posted on an anchor chart to refer back to throughout the CU. Students will explore the basic foundation of AI by watching a Discovery Education Video on Probability and Odds. This video will provide an introductory understanding of how probabilistic algorithms are created and used in the real world. After students discuss their thoughts on probability and algorithms, we will examine an example of how computers can operate independently of a human by watching the tape of Watson, the IBM computer, competing on Jeopardy. We will discuss the following essential questions in small groups: How is a machine like Watson a possibility? How do you think Watson can operate without a human's assistance? How can Watson recognize the speech of humans? How is Watson able to recall the answers he gives? At the end of the small group discussions, I will ask the students to respond in their journals to the following question: Is Watson intelligent? They will have to TAG their response.

As a homework assignment, my students will play rock, paper, and scissor against a computer (website provided in student resources). The first night they need to select novice and complete five rounds and then it will explain how the computer is choosing its move which is fascinating to me so I am sure the students will love this. The second night they will select veteran and repeat the same process. Each night they will be responsible for tracking results of the rounds and then TAG the following questions: What did you learn about computers? How do you think the computer gets better at playing? Homework throughout the unit will include bringing in current event articles about technology and AI to share during our class meeting times.

Game Play: Looking Ahead with Algorithmic Commands

The skill of looking ahead is very crucial. Looking ahead is when a student thinks about what they have just completed during a task or what they have been exposed to as they read a book or passage. Looking ahead requires a student to brainstorm all the possibilities that can occur after the action they completed or the information they received. This skill allows students to think about the logical series of steps they need to choose or follow to answer a mathematical word problem, equation, or science project.

This week we dive into how computers operate on a mechanical level like humans by looking ahead systemically. AI uses this strategy in game playing. I will introduce my students to the IBM‘s Deep Blue chess playing computer with a video of the match against Garry Kasparov, articles, and a power point slide of how the program worked. The slides will introduce the students to decisions trees. I will show them how for any one move there are different outcomes. There are numerous resources online to take screen captures of or find a template to print if you do not have a Smartboard. We will discuss why some outcomes are positive in terms of winning the game versus other outcomes that are negative because they will allow the opponent to win or stalemate.

First, my students need to grasp the concept of an algorithm. I will introduce my students to algorithms with flowcharts. Flowcharts are a great way to visualize algorithms. Students will learn how to diagram a set of instructions to mimic the process of algorithm development and to visualize algorithms. We will complete the lesson plans from course two of Code.Org, specifically “Graph Paper Programming” and “Real Life Algorithms: Paper Planes”. The early stages of course 2 will be mixed in with students creating algorithms for daily tasks as well as word problems.

After students have a fundamental understanding of algorithms, I will pass out slips of papers that have “simple” daily mechanical tasks, such as going down a slide, making a peanut butter and jelly sandwich, and walking out the door. The students will work in groups of two to think about the task and create a step by step set of directions to provide to another student to follow. I will tell the students who are following the directions to only use the commands they were given. If the person said to walk I will tell them to walk the opposite way or keep pretending to walk when they encounter a wall. After the students complete the instructions, I will ask the group to discuss what went wrong. I will ask them how they could have made the directions clearer. We will share our findings from the activity as a whole group and create an anchor chart for giving directions.

I will connect this lesson to a series of lessons where my students will use games to practice the skill of looking ahead and using decision trees to pick their next moves. To start, my students will play the game Tic-Tac-Toe like normal with a partner. Students will play Tic-Tac-Toe multiple times with their partner. I suggest each student have a different color so their moves stand out from each other. At the end of the allotted time to play, I will ask my students two questions. The first question will be for the students to tell me what move they think is the most important, second, third, etcetera. The second question I will ask my students will be to decide if they can figure out a way to win every time they play and explain. This will be the first activity where my students will acquire some personal background experience with algorithmic thinking without calling it that.

My students will be able to appreciate how much work it takes for weak AI to operate in the next stages of their game play. I will have them create a set of pre-defined rules for operation, to play a game as if they were a computer. They will have to anticipate their opponent's moves and the different options that will exist at each moment in the game beforehand. This will help them understand how mechanical weak AI is. There are multiple steps, or processes, that must be thought of or completed for any one action to occur. I want them to be able to comprehend how much goes into mechanical operations so they can appreciate the challenges scientist are faced with in trying to even think of achieving strong AI.

My students will explore their favorite games through a set of new eyes. I will create a list of my student's favorite games during our class meeting. I will ask students to raise their hand to tell the class their favorite game. I will ask them to explain why it is their favorite game and a quick description of how it is played. After we have made a decent size list of at least 6 to 8 games, I will ask my students if they think they could program a computer to play one of the games on the list. I am hoping they will say yes. If they do not it could be a great discussion about how some tasks seem very hard but with practice and determination they can be tried.

I will remind my students of the prior lesson with giving instructions for completing a daily task and remind them of how they must use precise vocabulary in their instructions. We will make a chart of transitional words and synonyms specific verbs and adverbs that may come up. I will then group students accordingly. For this activity I want groups and not partnerships. It will be important for the students to have multiple viewpoints as this activity will not be easy, purposefully.

Once they have created the instructions, a classmate from a different group will use the instructions to play the game, without any assistance, following the directions against a member from the group. The extra group members will be instructed to take notes on each play. I will guide them to focus on the following essential question as they observe the game play: “Is each move able to be completed, why or why not?”. We will record the games and discuss afterwards how the directions corresponded to the actual events and what might need to be modified. Questions we will discuss before and after will be: Will this work for every game? Can we simplify the process? How would we program computers to do this? What was involved for this to be carried out? This will allow them to develop the systematic thinking we want students to have when they attempt to problem solve.

To incorporate the experience they had creating their instructions from without assistance, I will allow them to practice with a set of mechanical instructions an actual programmer would use to provide a computer to play a game. This last activity of this week can be found in the teacher resource section with detailed plans under “Winning Games: The Perfect Tic-Tac-Toe Player”. Students will create an algorithm to play Tic-Tac-Toe again, this time utilizing scripted steps stated using first, second, then, if, and other technical terms, for each move they make. Students will create their algorithm using specific directions that cannot be edited. It will give them a chance to see the confines a computer program deals with, at a basic level. Teams will be given specific roles of player A or player B, before creating their algorithm. After they create their sequence they will compete against an opposite letter team. We will discuss as a class the results and make an anchor chart of our observations.

Machine Learning

Machine learning is a field that is concerned with the mathematics and algorithms that are necessary to create computers that can learn from experience. To introduce my students to the concept of machine learning, I will utilize the Wonderville website’s section on machine learning. Wonderville.com is a great science resource for student friendly descriptions of concepts and vocabulary especially for this unit. They utilize videos and games with animation. I will use the information from the Wonderville.com website to create a handout explaining machine learning including vocabulary, jobs in the field, practical applications in the real world, and fun online activities to look at. Students will read the worksheet with their partner, creating a 3-2-1 together. I will call my students back together after I feel they have had ample time and we will create a class bubble map for the topic.

The next day students will begin to understand how computer scientist have created an extensive set of applications and software that they use when they play games or interact with different technologies by playing a mini version of chess called Hexapawn. This game is over in 3 moves but has an extensive setup. Cs4fn.com has an activity titled “The Sweet Computer: Machines that Learn” that outlines everything you need and has the print outs. If supplies are an issue the game can be found electronically for students to complete on an iPad or for you to show through a projector/Smartboard.. The purpose of this game is to facilitate an understanding of how much thought must be put into the steps of an algorithm and how complicated the process of learning can be.

During game play when the "computer" loses it retracts to the last play and eliminates that move by taking the jelly bean out of the cup or eliminating that option in future games. We will discuss the morals and lessons they learn from our lessons during our class meeting times, partner talks, and group talks. Students should have relevant experience with figuring out some behaviors are negative and they need to eliminate them going forward.

The Hexapawn activity will prepare students for our next investigation in machine learning: programs that utilize learning from experience to make recommendations. This is one of the most useful and relevant activities because students can use this activity to find book talk partners, get book recommendations and share their reading interests. This activity can be replicated for favorite subjects, movies, or anything else you want your students to compare and find commonality with others. It will build a great sense of community as some students who feel they have nothing in common with each other may find out they do and vice versa. I will pose the following essential question to my students: How do Netflix and Amazon know what to movie or book to recommend to you? You could add Google but I do not feel my students are at the cognitive level to undergo a lesson on how the Google search bar utilizes machine learning. I will just summarize at the end of the lesson that Google uses a similar algorithm.

Rate each below using the following scoring system: -5 terrible -1 disliked 0 Have not read 1 Just Ok 5 Love it	
Book Title	*Rating*
Because of Winn-Dixie	
Bridge to Terabithia	
Frindle	
Holes	
Tuck Everlasting	
Wonder	

For each book: • Fill in your score in the first blank • Fill in your classmates score in second blank • Don't forget to write and key in any negative signs) **(Your Rating) X (classmates) =**	*Use a calculator to enter the equation on the left and record the result below for each book.* ***Compatibility Score***
(______) x (_______) =	
(______) x (_______) =	
(______) x (_______) =	
(______) x (_______) =	
(______) x (_______) =	
(______) x (_______) =	
Add up all the scores on the right for a final score:	sum= _______________

Before this lesson, I will have my student's list books they have loved as well as books they have found to be absolutely terrible. I will look through their lists to find books that appear on multiple lists to make a master list of at least 12 to 18 books. It doesn't matter whether they liked or disliked the book to make the master list. I just want to make sure I have options that multiple students have read. I will make a little template that has the master list and a column of empty boxes to the right to rate the book using the rating system (see below for a basic model). I will give my students a demo table for calculating their compatibility score and then they can redraw the table each time in their notebook. I will walk them through an example of completing the table (Ms. B compared to Mrs. G, their other teacher). I will leave this on the board as they do the activity. I will provide calculators to do the calculations and model entering the equations.

This activity utilizes negative numbers which my students do not work with. You need to use negative numbers so to differentiate you may want to do this in small groups or limit how many comparisons they do. I will give my students a set amount of time to do as many as they can. The rating system uses negative numbers to code whether they disliked the book (-1) or detested the book (-5). It uses a zero if they have never read the book and positive is they liked the book (1) or loved the book (5). They complete their rating. I will make mine use pen to do their rating so they do not change it to be like their friends. They will compare their ratings with the other students in the class, utilizing positive and negative rating by multiplying their score for each book with each classmate. They then add up all the results of each book to get an overall score. I will provide a list of classmates with an additional column for them to put their compatibility rating next to each classmate. Students will be able to takeaway a list of students who have similar tastes to them. They can refer to the list to identify students that would make great book recommendations for them, suited to their tastes. Instead of telling students this directly you can pose one of the following questions to them: “Why (or how) is this list relevant to you?” or “Now that we have this list, what can we do with it?”. You may want to provide two class periods if you feel your students will actively participate to give them additional time to get more scores.

Basic Coding Practice

This is the part of the unit where my students will get technological hands-on experience, practicing how to code. They will use algorithms of written directions the computer can understand in order to accomplish tasks such as, moving objects on the screen from one place to another. They will complete an hour of code at code.org. My students are obsessed with the movie “Frozen” and the website has an option to use the theme of “Frozen” or “Angry Birds”. After completing course 2 and the hour of code students will be provided the option of using the “Play Lab” and “Flappy Code” to practice creating their own short animation application. During this time students will have an optional assignment to create their own piece of code in the form of a computerized game or story that will be published on Scratch.com.

Reasoning and Planning

The skill of reasoning, or inferring about possible outcomes and selecting the best choice available, are important aspects of being able to create and carry out a plan of action. This skill is important for reading and writing as well as mathematics. Mathematics is built on a foundation of carrying out a set of specific steps following one of four operations to achieve an end result. In order to answer a scenario or story problem, students must be able to dissect the sentences to pull out key information and create an equation to solve. In fourth grade our students are often posed multi step problems that require different operations to solve the problem. Part of proving proficiency is completing a test where there are usually multiple choice answers. A successful test taker reasons through which answers are viable and which answers do not fit the equation.

This week is a crucial mathematical content week where students apply their understanding of the importance of sequencing when creating and using algorithms so that the desired end result is achieved every time. I will remind students of the Tic-Tac Toe activity and the different games they played using directions that were supposed to be followed word for word as a computer would. I will inform my students that we will apply the same concept, setting up a pre-defined set of operations, for completing a mathematical equation. We will use the same questions to analyze our directions as we did in the game playing activity, with a heavy focus on will the "computer" have the product we want?

Students will create instructions that utilize algorithmic thinking to explain how to apply a mathematical strategy, they have learned this year, to achieve a correct answer. Students will be given an equation, either multiplication, addition, subtraction, or division based on what I know they can handle, where they must create a step by step instruction to achieve the desired right answer. To differentiate for higher students, you could provide them a multi-step equation. To differentiate for lower students you can provide them sentence frames, or starters, using the technical vocabulary and blanks for them to add detail. Strategies my students have learned at this point of the year include: expanded form, jumping on a number line, quick pics for adding and subtracting, array model, break apart, the box, and the cheating hangman. In my classroom students are challenged to apply their understanding of concepts to the real world and model their thinking by showing their work. Therefore, they will also create a realistic story problem with a visual representation, work, for their equation.

The most important part of this activity in terms of the purpose of this CU is for students to present their directions to their classmates. Students will read the story problem to the class, give the step by step instructions they created, and then see if the work of their classmates matches their visual representation of the steps. Their classmates will be instructed to follow the directions as they are stated. For example, if they said draw a box, which is a very general direction, I would want my students to draw different size and shape "boxes". I would hope one of my students would actually draw a "box" 3-D style on their paper. Another example, if they said "carry the ten", I would want some students to put a ten regardless of the actual digit and maybe even "carry" it to the wrong column if they did not specify. Afterwards, we will discuss the differences in the visual provided by the groups and the end results from their classmates. This will facilitate a discussion on the importance of precise vocabulary when giving directions. The use of first, second, if, then, top, bottom, and other directional words are important especially in mathematics. To wrap up the activity students will respond in their journals about the importance of following steps and showing/checking work using this activity in their explanation.

Culminating Activity

Students will create a nonfiction magazine, as a class, on Artificial Intelligence. Current Event articles that are shared at our class meetings every week will be available for research and review, as well as a digital footprint of all the activities we completed. I take pictures of everything we do to share on Remind with my parents and to keep for a digital scrapbook at the end of the year. Students will have access to everything including photos to create each piece. We will discuss the roles needed for the classroom to function as a true magazine department would run. We will decide on what pieces should be our primary focus and how the layout will look. We will utilize the nonfiction text structures (cause and effect, sequence, problem-solution, etcetera) along with the nonfiction text features. I will work closely with my co-teaching partner to use the teaching points on nonfiction text she has taught as I conference with each student on their articles. We will utilize the algorithmic thinking we learned about to plan and carry out this project. I would love for them to publish an algorithm from our math activity for other students to complete and then provide the answer with work on the back page like do with a crossword. I am hoping they may have some interesting pieces of their own to add. In the end the students will be able to publish the magazine for the upper grades to read during their independent nonfiction reading time that is a part of their reading workshop time.

Appendix 1: Implementing Teaching Standards

Math

CCSS.4.OA & .4.NBT.4, 5, 6

- Generate and analyze patterns as students gain familiarity with factors, multiples, and operations with whole numbers to solve problems.
- Using place Value to understand numbers, their properties, and use those to develop strategies for performing operations in multi-digit arithmetic.

Reading

CCSS.Literature.RI.4.7 & .4.9

- Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text.
- Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

Writing

CCSS.Literacy.W.4.2

- Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Science

- This CU promotes Scientific Inquiry, which is not a standalone standard. Instead it is weaved throughout the different standards within each grade level.. This unit promotes STEM strategies and concepts.

Appendix 2

Student Resources

- http://www.discoveryeducation.com/
- http://www.nytimes.com/interactive/science/rock-paper-scissors.html?_r=0
- http://scratch.mit.edu/
- http://code.org/
- www.wonderville.com

Teacher Resources

- Watson Resources: http://www.nytimes.com/2010/06/20/magazine/20Computer-t.html?pagewanted=all&_r=0
- http://www.theatlantic.com/magazine/archive/2013/03/the-robot-will-see-you-now/309216/
- Machine Learning: http://www.wonderville.ca/asset/science/88
- Hexapawn: http://www.cs4fn.org/teachers/activities/sweetcomputer/sweetcomputer.pdf
- Tic-Tac-Toe: http://www.cs4fn.org/teachers/activities/winatoxo/winatoxo.pdf

Annotated Bibliography for Teachers

"Computational Fluency: Algorithms and Mathematical Proficiency: One Mathematician's Perspective." NCTM.org. January 1, 2003. Accessed October 27, 2014. http://lesage.blogs.uoit.ca/wp-uploads/2010/08/Computational-fluency-NCTM-Feb-2003.pdf.
This is a great resource to demonstrate how to explain mathematical algorithms.

Bhatt, M. (2013)"Impact of Increased Computing Power through Artificial Intelligence." Academia.edu. Accessed October 26, 2014. http://www.academia.edu/5943391/Impact_of_Increased_Computing_Power_through_Artificial_Intelligence.
This article explains the relationship between AI and current engineering.

Davidson, C. "Why We Need a 4th R: Reading, WRiting, ARithmetic, AlgoRithms." January 25, 2012. Accessed May 20, 2014 http://dmlcentral.net/blog/cathy-davidson/why-we-need-4th-r-reading-writing-arithmetic-algorithms.
This was a central article for me in choosing what direction I would take this unit.

Futschek, G. "Algorithmic Thinking: The Key for Understanding." January 1, 2006. Accessed November 27, 2014. http://publik.tuwien.ac.at/files/PubDat_14030
This is a great resource for explain why algorithmic thinking is so vital in education.

Levesque, M. (2012)"Teaching Algorithmic Thinking." Rwxweb. Accessed November 27, 2014. https://rwxweb.wordpress.com/2012/01/31/teaching-algorithmic-thinking/.
This is another article that strengthened my rational.

Resnick, M. "All I Really Need to Know (About Creative Thinking) I Learned in Kindergarten." Mit.edu. Accessed November 22, 2014. http://web.media.mit.edu/~mres/papers/kindergarten-learning-approach.pdf.
This is a great read for understanding the importance of the problem solving approach.

Russell, Susan Jo. "Developing Computational Fluency with Whole Numbers." *Teaching Children Mathematics*, November 1, 2000.
This article will help with understanding the math portion of the CU.

Russell, Stuart J., and Peter Norvig. Artificial Intelligence: A Modern Approach. Englewood Cliffs, N.J.: Prentice Hall, 1995.
This book is available online as a free download. It's thoroughly explains AI.

Searle, J. (1980)." Minds, brains, and programs" The Behavioral and Brain Sciences. 3, 417-415.
This is a great resource to dig deeper into what weak and strong AI is.

Tsalapatas, H., Heidmann,O,., Alimist, R., and Houstis, E. (2012)."Impact of Increased Computing Power through Artificial Intelligence." Academia.edu. Accessed November 26, 2014.
http://www.academia.edu/5943391/Impact_of_Increased_Computing_Power_through_Artificial_Intelligence.
This article explains the benefits of a current game playing intervention program.

Turing, A. M. "I.—Computing Machinery And Intelligence." *Mind*: 433-60.
This paper is an essential part of the seminar and CU. This is a must read.

Notes

[1] (Bhatt 2013) p. 1
[2] (Tsalapatas, H., Heidmann,O,., Alimist, R., and Houstis, E. 2012) p. 1
[3] (Davidson 2012) p.1
[4] (Bass 2003) p. 1-2
[5] (Resnick) p.1-3
[6] (Resnick) p.1-3
[7] (Futschek 2006) p. 2
[8] (Futschek 2006) p. 2
[9] (Russell and Norvig 2010) p. 20
[10] (Russell and Norvig 2010) p. 1040
[11] Turing) p. 1
[12] (Searle 1980) p. 417
[13] (Russell and Norvig 2010) p.20
[14] (Levesque 2012) p. 1
[15] (Russell) p. 10