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BOARD # 71: Integrating Machine Learning into Middle and High School Curricula using Alzheimer's Disease Prediction Models

Dr. Tayo Obafemi-Ajayi, Missouri State University

Dr. Tayo Obafemi-Ajayi is an Associate Professor of Electrical Engineering at Missouri State University in the Engineering Program, a joint program with Missouri University of Science and Technology (S&T). She obtained her B.S and MS in Electrical Engineering and a PhD in Computer Science from Illinois Institute of Technology.

Dr. Naomi L Dille, Missouri State University
Dhanush Bavisetti, Missouri State University
Mrs. Sherrie Ilene Zook

Integrating Machine Learning into Middle and High School Curricula using Alzheimer's Disease Prediction Models

Naomi Dille,[1,†] Sherrie Zook,[2,†], Dhanush Bavisetti [3] and Tayo Obafemi-Ajayi[3,*]

[1]Cherokee Middle School, Springfield Public Schools, Springfield, MO 65802 USA
[2]Kickapoo High School, Springfield Public Schools, Springfield, MO 65802 USA
[3]Missouri State University, Springfield MO 65897 USA
†: Both authors contributed equally.
[*]tayoobafemiajayi@missouristate.edu

Abstract: This study explores the integration of machine learning (ML) concepts into the curriculum for 6th to 12th-grade students thus, addressing the growing importance of computational skills in the STEM workforce. Teachers play a pivotal role as the principal pedagogical agents in fostering students' motivation and readiness to engage in postsecondary education in STEM career pathways and eventually, the STEM workforce. Thus, we hypothesize that introducing teachers to innovative machine learning (ML) research methodologies—particularly those applied to real-world problem solving—can significantly enhance STEM learning and research experiences in grades 6 through 12.
This project is an outcome of a Research Experience for Teachers (RET) summer program designed to immerse secondary educators in authentic research environments. During the program, participating teachers engaged in a ML project centered on predicting the severity of Alzheimer's Disease using data collected from smart home sensors—a real-world application of ML in healthcare. The teachers were introduced to foundational computing concepts through Scratch, developed basic ML pipelines with interpretability features using ORANGE, and explored automated machine learning through the Aliro platform. Each tool provided a progressively advanced exposure to ML concepts while maintaining a consistent predictive modeling framework.
The RET framework emphasized the iterative nature of research, model performance evaluation, and the importance of balancing model fit with generalizability. Teachers were able to learn ML concepts by repetition and reinforcement using the three different software suites (ORANGE, Aliro, and Google Colab).
Subsequently, at their local schools, teachers integrated computational thinking and ML concepts into existing curricula across Mathematics, Algebra, and Statistics courses. Despite encountering challenges—including limited instructional time and technological constraints imposed by district policies—teachers successfully introduced foundational ML principles through both formal instructional modules and informal classroom activities. This study contributes to the expanding body of STEM education research by illustrating practical strategies for empowering secondary educators to integrate machine learning and computational thinking into their instruction. The findings underscore the potential for interdisciplinary learning and the cultivation of critical thinking skills that are essential for preparing the next generation of STEM professionals.

1. Introduction

STEM (Science, Technology, Engineering, and Mathematics) fields are widely regarded as intellectually prestigious and economically advantageous in our contemporary society. They represent a critical domain of human capital development, offering substantial opportunities for social mobility and economic advancement. Notably, an estimated 71% of current jobs demand proficiency in STEM-related skills, underscoring the growing importance of STEM competencies in the modern workforce [1]. The rapid proliferation and integration of Artificial Intelligence (AI) across nearly all sectors of society is fundamentally reshaping the skillsets required for participation in the modern STEM workforce [2, 3]. As such, foundational knowledge of AI is becoming increasingly essential for students preparing to enter 21st-century STEM careers. Despite this growing demand, exposure to computational thinking, scientific computing, and research methodologies remains limited within the traditional

K–12 curriculum. Teachers serve a pivotal role in shaping students' academic trajectories and career aspirations, particularly in STEM fields. As the primary facilitators of classroom instruction and curricular implementation, educators are well-positioned to influence students' engagement with emerging technologies. This study is undergirded by the hypothesis that engaging teachers in authentic machine learning (ML) research experiences can enrich classroom instruction and foster greater student interest in STEM disciplines and career pathways [4, 5].

This study is an outcome of an NSF sponsored Research Experience for Teachers (RET) designed to expose teachers to applied AI research projects with societal impacts. The rationale is that teachers will bring the knowledge and skills they acquired back into their science and mathematics classes and curriculum. Our overall goal was to equip teachers with an awareness of the importance and use of AI/ML to solve practical problems of societal values. Thus, they can be positioned to motivate their students about the importance of AI. Our team consisted of 3 middle school and high school teachers who were exposed to an ML research project related to prediction of Alzheimer's disease over the course of six weeks. The teachers self-reported that little to no programming experience prior to this. The summer research experience was structured to build confidence through a gradual increasing level of exposure to ML concepts and Python programming. Key components of the integration involved introducing fundamental computing concepts via Scratch [6], constructing basic machine learning pipelines with explainability in ORANGE [7], and conducting automated ML using Aliro [8]. Additionally, the study familiarized the teachers with Python programming principles through Google Colab [9].

This paper describes the process of empowering teachers, from a non-coding background, toward an understanding of machine learning fundamentals and their application in real-world scenario, to subsequently motivate and guide students, having journeyed through the experience themselves. Alzheimer's disease (AD), in particular dementia, is a significant and growing public health challenge, particularly as the global population ages [10]. By the year 2030, studies indicate that the number of people aged 65 to 74 will be about 3% of total population [11]. Some studies indicate that 75% of dementia cases are diagnosed at a moderate or advanced stage [12]. In recent years, researchers have harnessed ML to analyze vast and complex datasets—from brain imaging and genetic profiles to clinical records—to detect subtle changes associated with Alzheimer's well before traditional methods might. This early detection is crucial, as it opens the door for timely, targeted interventions that can slow disease progression and improve patient outcomes [13]. In essence, applying machine learning in this context not only deepens our understanding of Alzheimer's but also underscores the broader potential of data-driven approaches to offer more humane and potentially life-saving solutions in healthcare. This notion appealed to the teachers and made it easier for them to personalize the healthcare application to their students. This concept resonated with the teachers, thereby facilitating the customization of their ML project experience as a motivating tool to encourage their students to care about computational concepts at large. Though AD is not associated with the 6th – 12th grade age group, it is very relatable since most of the kids have aging grandparents or relatives, who may potentially be impacted by this disease. Some of these kids might come from households that are currently having to care for an ailing relative suffering from AD or Dementia at large.

We demonstrate how our team was able to use the AD classification project as a springboard to integrate ML, and computational thinking at large, in 6th – 12th grade mathematics and science curricula and informal classroom learning experiences. The hypothesis is that connecting abstract computing principles to practical ML applications in solving real-world problems through research-based exploratory learning will attract and engage students to engage in AI/ML project activities and be better equipped for an AI STEM workforce. This study is work in progress. Despite facing challenges such as time constraints and technological limitations due to school district policies, we present the framework utilized by our team to successfully incorporated ML concepts into existing curricula.

School Setting

In this section, we briefly describe the school setting in which the study is implemented. Springfield Public Schools (SPS) is the largest K-12 district in Missouri, serving over 24,000 students across 50 schools. The district reflects the socioeconomic and ethnic diversity of the region, with approximately 60% of students identifying as White, 13% Hispanic, 7% African American, 4% Asian, and 16% representing two or more races or other ethnicities. About 55% of students qualify for free or reduced-price lunch, highlighting economic disparities within the district. SPS offers programs to support all learners, including English Language Learners (ELL) services, gifted education, and special education. One SPS high school (Kickapoo tagged as HS-1) and middle school (Cherokee tagged as MS-2) were involved in this study. The study was conducted under the guidelines of the SPS research review committee from the Data Analytics and Accountability department.

High School HS-1 is home to around 1,800 students, with a slightly less diverse demographic profile. About 75% of students identify as White, 10% Hispanic, 5% African American, and 10% represent Asian, multiracial, or other ethnic groups. Roughly 35% of the students qualify for free or reduced-price lunch, indicating a more affluent student population compared to other schools in the district. HS-1 is recognized for its high academic performance, extensive AP and dual-credit courses, and competitive athletics programs. Middle School MS-2 serves approximately 800 students and maintains a demographic profile similar to the district's averages, with about 60% White, 15% Hispanic, 10% African American, 5% Asian, and 10% multiracial or other ethnic groups. Around 50% of students qualify for free or reduced-price lunch. The school is known for its STEAM (Science, Technology, Engineering, Arts, and Math) focus, which integrates hands-on, project-based learning to foster critical thinking and innovation. This demographic composition provides opportunities for teachers to employ inclusive and culturally responsive teaching practices, fostering an equitable learning environment that meets the diverse needs of all students.

Research Experience for Teachers Summer Learning Environment

The Computer Science Research Opportunity for Smart Environments (ROSE) RET program provided the launchpad to develop and implement this project. Over a 6-week period, the teachers were introduced to Python programming, smart home related research, and guided in integrating programming and research concepts into their middle and high school curricula. The project conducted by this specific team of three teachers focused on building a ML-based prediction model that leveraged data from smart home environments to classify individuals into specific cognitive health categories. For identifying cognitive decline, detecting abnormal behaviors in smart homes is crucial. Various studies have focused on anomalies that can range form missed activities, like forgetting to cook or clean, to incorrect task sequences such as preparing food before gathering ingredients. The underlying hypothesis of the summer research project was that identification of key features related to anomaly behavior detection, in smart home derived data, could enhance the precision of AD detection and classification. The overall strategy applied with the teachers was to

1. Introduce fundamental computing concepts via Scratch [6]
2. Construct basic ML pipelines with explainability in ORANGE
3. Conduct automated ML using Aliro.
4. Explore Python programming using Google Colab.

Scratch was developed as an approach to programming that would appeal to people who hadn't previously imagined themselves as programmers [6]. It provided a great foundation to introduce the teachers to computational thinking and basic programming concepts. Scratch has been shown to greatly facilitated learning of more advanced material in high school: less time was needed to learn new topics, there were fewer learning difficulties, and they achieved higher cognitive levels of understanding of most concepts [14]. Orange is a software product for ML and data analysis through Python scripting and visual programming [7]. Orange provides a non-intimidating platform to introduce our teachers, as non-technical users, to ML concepts such as classification, pre-processing, data reduction, visualization, explain-ability, etc [15]. Aliro is an open-source software package designed to automate ML analysis through a web interface [8]. It has a built-in ML recommender system that guides users through, (a) Choosing the right machine learning technique for a particular problem or dataset, and (b) Configuring hyperparameters to optimize the chosen algorithm's performance. It is especially suited for researchers without computer science/data science training. By automating much of the complexity in data analysis, Aliro accelerates research and help users focus on drawing insights from data rather than getting stuck in the weeds of ML model configuration. Google Colaboratory is a cloud-based Jupyter notebook environment freely provided by Google [16]. It is a great platform to introduce some advanced Python programming concepts as well as ML libraries such as Pandas, NumPy, scikit-learn, and Matplotlib. Teachers were able to learn ML concepts by repetition and reinforcement using the three different software suites (ORANGE, Aliro, and Google Colab). Applying this building block approach to ML programming empowered the teachers to take ML/AI modeling back into their classrooms.

Methods

To integrate the summer learning experience in the classroom, the overall approach centered around instructor empowerment, structured lesson design, informal learning opportunities, and evaluation. Instructor empowerment involved being in the research project. This reoriented their perspective and ability to see possibilities of what they could do in the classroom.

Lesson plans

To create ML-aligned lesson plans, the teachers started by reviewing the required state standards, identified which ones aligned well with coding, and then worked backwards to design lesson plans that integrated both coding and the standards seamlessly. Note that, given the technology limitations for their course offerings in the public school setting, they were only able to utilize online coding program, Scratch. This limited the extent of ML concepts that could be explored in the structured learning setting of the classroom, such as with Orange or Python. Scratch provided an interactive platform for teaching 6th-grade Missouri math standards, incorporating project-based learning with LEGO Mindstorm cars and coordinate plane activities. These activities provide hands-on, engaging ways to connect coding with math standards, fostering both computational thinking and mastery of grade-level concepts. This provided a framework to implement advanced ML knowledge into STEM education by developing practical methodologies to teach complex ML principles through easily accessible tools.

For the high school students, an intentional choice was made to utilize Scratch, rather than Python for programming due to the influence of AI tools (such as ChatGPT) that can provide the entire Python code script. Scratch seemed a little more foolproof, as students still had to find all of the necessary blocks themselves, and attach and embed them appropriately, even if they sought the answer from ChatGPT. The programming exercises covered the following topics included in the algebra 1 curriculum: solving 1 step equations, solving 2 step equations, finding the intercepts from the equation of a line in standard form, finding the terms of a sequence using initial term and common difference or common ratio, and finding the nth term of a sequence. The common core standard used in both solving equations programs and solving for the intercepts is HSA.CED.A.4. Students always struggle with rearranging equations and solving literal equations. This was a successful way to integrate the standard in a more novel presentation.

Informal Learning Opportunities

The High School teacher shared with their statistics class how data was handled during the RET research program. They discussed how some students had missing data or declined to answer certain questions, and how they used the mean to fill in those gaps, making the data usable for analysis. The teacher would not have known how to do this if they had not learned about it over the summer. In their class project, students were limited in how they conducted regressions, but when the teachers worked on AD research during the summer, they had to use ML software which were capable of weighing data from multiple sensors and incorporating various variables beyond two. In algebra class, the teacher related frustration tolerance to their summer coding experiences, explaining how learning something new, especially coding, can be challenging. The 6th grade teacher also had discussions about dementia and Alzheimer's, noting that most students probably knew someone affected, though it might have been diagnosed late. The program the teachers worked on aimed to help with earlier diagnoses and provide interventions for the elderly population, highlighting how machine learning plays a significant role in these early interventions. The students also identified other areas where machine learning could be applied, like helping police departments track predators on social media, and recognized how learning to code and use machine learning could open up many career possibilities.

Evaluation

To assess the impact of the pedagogical approach, the teachers conducted pre- and post-surveys with their students. The survey questions focused on five categories: Interest in science and technology, Available resources for learning, Preferred STEM activities and subfield for computer science, School environment, Career interest and preparation, Demographics.

They also completed reflection exercises. The parents/guardians had to sign consent forms to give approval for their students to be included in the data collection activities. The teacher conducted observations and had a set rubric that identified success criteria. Students evaluated each other using the same rubric in order to provide assistance and feedback.

This project was conducted under the guidance and approval of the school district data analytics and accountability office.

Both programs developed for sequences address Common Core Standard HSF.BF.A.2. It was imperative to ensure that these programs aligned with Algebra I standards, given the strict classroom time constraints and the limited opportunities to cover additional topics. Examples of the teaching standards developed to align middle school mathematical concepts using Scratch programming is illustrated in Table 2. The high school standards and the corresponding Scratch programming applications are presented in Table 1.

Results

24 students across 2 algebra 1A classes at the high school participated in programming lessons and completed similar surveys. Not all students were able to complete all activities due to absences. The class meets 5 days per week for 90 minutes each day. Algebra 1A is an almost exclusively freshman class consisting of mainly low achieving math students who were deemed to require extra time to master concepts. Those passing Algebra 1A move on to

Table 1: High School Standards encoded using Scratch Programming.

Teaching Standards	Application in Scratch
6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.	Hacker name: use variables to learn how to use the various blocks in Scratch to create a program to give their "hacker name." Although not using variables to represent numbers, the thought process of using variables is still the same.
A1.CED.A.4 Solve literal equations and formulas for a specified variable that highlights a quantity of interest. **HSA-REI.A** Understand solving equations as a process of reasoning and explain the reasoning. **HSA-REI.B.3** Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.	One-step equations: Students will write a program that will solve an equation for x in the form x + a = c or ax = c. This involves the ability for students to solve and apply literal equations.
A1.CED.A.4 Solve literal equations and formulas for a specified variable that highlights a quantity of interest. **HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA-REI.A** Understand solving equations as a process of reasoning and explain the reasoning. **HSA-REI.B.3** Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.	Two-step equations: Students will write a program that will solve an equation for x in the form ax + v = c. This involves the ability for students to solve and apply literal equations.
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSF-LE.A.2** Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs **HSF-BF.A.2** Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.	Sequences (recursive): Students will write a program to find the nth term of a function by repeatedly multiplying and/or adding the common factor or difference. The program will perform multiple iterations by asking the user to continue the operation or end it. This will involve creating loops in Scratch.
HSF-BF.A.2 Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms. **A1.CED.A.4** Solve literal equations and formulas for a specified variable that highlights a quantity of interest. **HSA-REI.A** Understand solving equations as a process of reasoning and explain the reasoning.	Finding intercepts: Students will take the equation of a line in standard form and solve for the x- and y-intercepts.

Algebra 1B in the spring semester. 22 students were involved at the middle school level. The assessments aspect of the research was conducted under the guidance of the SPS Data Analytics and Accountability office. Parental consent forms had to be signed prior to the students participating in pre and post activity surveys.

Many of the concepts learning through the RET summer program was also implemented in the AP/Dual Credit Statistics class, although though there were no formal lesson plans. The integration in these courses demonstrated the power of informal learning. All the students enrolled in the course are required to complete a semester-long research project focused on real data analysis. The AD ML summer project enabled the teacher to incorporate preprocessing ML concepts into her classroom instruction. The students acquired skills in performing essential data curation steps using Google Sheets and stapplet.com, and explored data imputation techniques as an important part of ML projects. Moreover, integrating the visualization aspects of the ML pipeline into the Statistics classroom was achieved seamlessly. The teacher reported increased confidence, feeling well-prepared to assist students, respond to their questions, and provide guidance, especially on topics such as missing data, chart creation, and ethical use of AI. The discussion of ML programming tools such as Orange and Aliro and the methodologies employed during the summer project were of significant interest to the students.

During the high school lessons, it was noteworthy to observe students assisting one another. Since approximately half of the class had prior experience, they were able to guide their peers in locating the necessary blocks.

Table 2: Middle School Teaching Standards Alignment Using Scratch Programming.

Teaching Standards	Application with Coordinate Graphs
6.NS.C.6.C Find and position integers and other rational numbers on a coordinate plane.	Students will program Scratch sprites to specific coordinates, reinforcing their understanding of integer placement on the coordinate plane.
6.NS.C.7.C Interpret statements of inequality as positions on a number line.	Scratch will allow students to code sprite movements based on comparisons of rational numbers, demonstrating inequalities visually on the graph.
6.NS.C.8 Solve problems by graphing points in all quadrants.	Students will solve problems by directing sprites to navigate all four quadrants, combining math skills with computational logic.
5.G.A.1 & 5.G.A.2 Graph points and interpret data on a coordinate plane.	Younger students can practice plotting points and analyzing graphs by programming Scratch sprites to move to specific locations and observing their paths.
3.NF.A.2.B & 4.NF.A.2 Understand and compare fractions.	By coding sprites to fractional positions on the graph, students reinforce concepts of fractions and their representation in spatial contexts.
4.NF.C.6 Use decimal notation for fractions.	Scratch allows for precise placement of sprites at decimal positions, integrating decimal fractions into coordinate plane activities.
	Application with LEGO Mindstorm Cars
6.SP.A.3 Recognize the measure of center summarizing numerical data.	Students will code LEGO Mindstorm cars in Scratch, collect performance data e.g., distance or speed, and analyze the mean, median, and mode.
6.SP.B.4 Display data on a number line or graph.	Using the gathered data, students will code visual data displays such as bar graphs or line plots in Scratch, helping them understand data representation.
6.SP.B.5.B Describe the nature of the data.	Students will describe attributes like car speed or travel distance, including how measurements were taken and their units.
6.SP.B.5.C Calculate and interpret measures of center.	Students will compute and interpret measures like mean and median using Scratch, potentially coding their own formulas to reinforce these statistical concepts.
	Application with Expressions, Equations, and Patterns in Scratch
6.EE.A.2 Write, read, and evaluate expressions involving whole-number exponents.	Students can use Scratch to create a program that calculates values for expressions with exponents, such as $232^3 23$ or $32+43^2+432+4$, reinforcing their understanding of exponents through coding.
6.EE.B.5 Understand solving an equation or inequality as a process of answering a question.	Scratch can be used to create simple games or animations where students input values to solve equations or inequalities, receiving instant feedback on their solutions.
6.EE.C.9 Use variables to represent two quantities in a real-world problem.	Students can write code in Scratch to simulate real-world scenarios, like tracking the distance traveled over time by a moving object e.g., a sprite or car, using variables for distance and time.
	Application with Geometry and Measurement in Scratch
6.G.A.1 Find the area of polygons, including by composing into rectangles or decomposing into triangles.	Students can use Scratch to draw polygons and calculate their areas by breaking them into smaller shapes, visualizing the mathematical process interactively.
6.G.A.3 Draw polygons in the coordinate plane given coordinates.	Scratch's coordinate system can be used for students to code the drawing of polygons by placing points and connecting lines, reinforcing spatial reasoning.
6.G.A.4 Represent three-dimensional figures using nets made up of rectangles and triangles.	Students can create animations in Scratch that model 3D shapes and their corresponding nets, making abstract concepts more tangible.
	Application with Ratios and Proportional Relationships in Scratch
6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a relationship.	Students can program Scratch to create interactive examples of ratios, such as scaling objects or comparing quantities in a visual simulation.
6.RP.A.3 Use ratio and rate reasoning to solve real-world problems.	Scratch can simulate scenarios like converting units e.g., miles to kilometers or scaling recipes, allowing students to manipulate ratios and see the outcomes dynamically.
	Application with Statistical Thinking
6.SP.B.5.D Relate the choice of measures of center and variability to the shape of the data distribution.	Students can analyze data distributions generated by Scratch simulations and identify the most appropriate measures of center and variability, such as standard deviation or range.

Students also collaborated to debug each other's programs. Many of them created projects that surpassed the stated requirements. For instance, some students added buttons to prompt the user for the type of sequence and, based on the chosen option, directed the program along one of two distinct paths. Several students inquired about the next programming lesson, indicating that they found both the process and the challenge enjoyable.

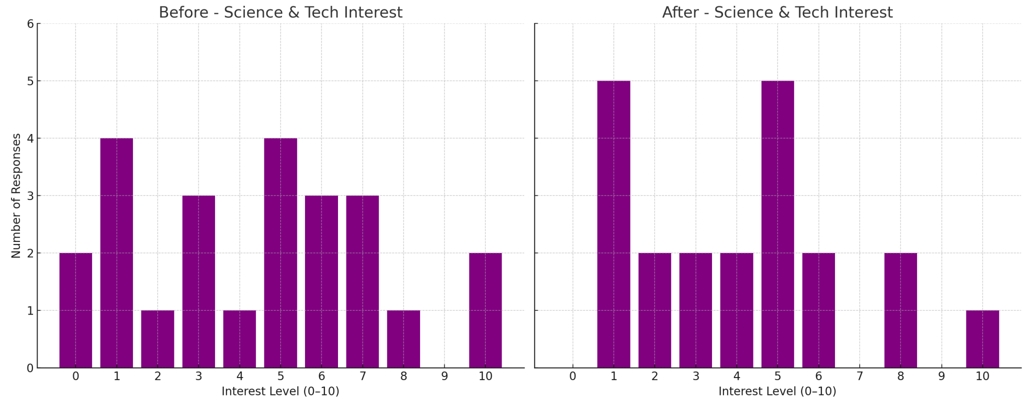
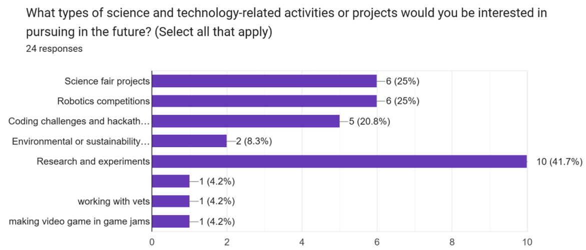
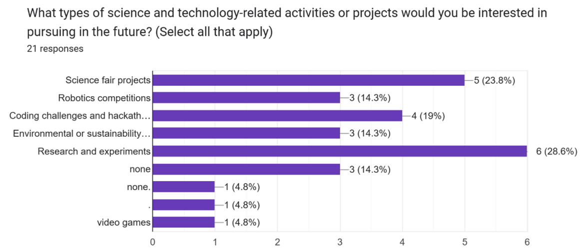


Fig. 1: Comparison of self-reported interest levels in science and technology before and after intervention.

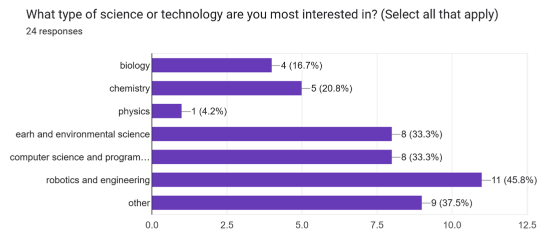


(a) Before

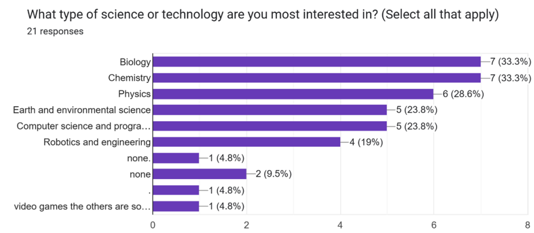


(b) After

Fig. 2: Analysis of Interested STEM activity pre and post Intervention.



(a) Before ...



(b) After ...

Fig. 3: Analysis of Interested STEM area pre and post Intervention.

At the middle school level, Scratch's flexibility makes it a powerful tool for visualizing, simulating, and interacting with abstract mathematical concepts. By combining coding with Missouri 6th-grade math standards, students develop computational thinking and problem-solving skills while deepening their understanding of key mathematical principles. Because of this, Scratch can be used to teach several other 6th-grade Missouri math standards, especially those that involve patterns, operations, expressions, and geometry.

Classroom discussions about ML prediction models were facilitated by the teachers by presenting their RET final research posters to their students. The students expressed interest in developing their own prediction models based on labeled data. Even though students could not use programs such as Orange and Aliro due to hardware and district limitations, the discussion of such programs and the libraries learned fueled their desire to divulge into AI related fields.

Conclusion

This study contributes to the growing body of literature on STEM education by demonstrating practical approaches to introducing complex ML concepts to secondary school students with a basic computational tool such as Scratch Programming. Through informal discussions of application of ML to real world applications such as prediction of AD, the teachers were able to motivate the students to engage in computational thinking related classroom activities. It highlights the potential for interdisciplinary learning and the development of critical thinking skills essential for future STEM professionals. Students exhibit strong interest in science and technology, particularly in Biology, Robotics, Physics, and Computer Science. However, the data highlights opportunities for improvement in hands-on learning, collaborative projects, and career support resources. Expanding mentorship programs, offering real-world projects, and enhancing diversity could significantly enhance student engagement and career readiness. Future work includes a thematic analysis of the student reflective surveys as well as assessing the impact of the RET experience on improving teacher pedagogic effectiveness. Nevertheless, these findings illustrate that real-world applications of ML/AI methods can significantly transform the learning environment by motivating and equipping both teachers and students to explore the technology.

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