Teacher-Created STEM Lesson Modules for Middle School via ImageSTEAM Workshops in Georgia

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Introduction

An interdisciplinary team of researchers (PIs) and Georgia educators collaborated in conducting the summer workshops over four years through the NSF-funded Innovative Technology Experiences for Students and Teachers (ITEST) program. The team consisted of individuals with expertise in computational cameras, AI, visual media, multidisciplinary engineering, sociology, STEM education, and media arts and sciences. A total of 37 Georgia teachers participated in the workshop and created lesson modules to implement in the middle school curriculum. A total of eleven lesson modules co-created by teachers from the Georgia AI Workshop Series, and are currently published on the *ImageSTEAM.org* platform. These modules span multiple disciplinary areas, including Engineering and Integrated STEM, English Language Arts (ELA) and Social Studies, Mathematics, and Science.

The co-created lesson modules are distributed across content areas as follows. Two modules were developed in Engineering and Integrated STEM**:** Understanding the Universal System Design *and* Designing Assistive Devices Using Pixlr X and Tinkercad. Three modules were created in ELA and Social Studies**:** Mexican Art History and AI Image Classification, The Middle East Water Conflict, *and* Visualizing African Population and Trade. In Mathematics**,** two modules were co-created: Surface Area and Volume Using Tinkercad *and* Convex and Concave Identification. The Science domain includes four modules**:** Plant versus Animal AI Classification, Distinguishing Acids, Bases, and Indicators Using Teachable Machines, Plant Leaf Identification, *and* Translucent, Transparent, and Opaque.

Two additional co-created lesson modules, not yet available on ImageSTEAM.org, include *Create Your 3D Eye: A Lesson Module for Grades 6–8*, developed through the ImageSTEAM Teacher Workshop, and *The Cotton Gin and Westward Expansion: AI Concepts in Middle School Social Studies*. These modules will be available later this summer on the website. The lesson module development followed a design approach through computational cameras and the STEAM disciplines and a theoretical framework which are briefly described in the next sections.

Workshop Design

A computational camera approach guided the implementation of the AI workshops. The workshops were initially designed to provide professional development for middle school teachers in STEM disciplines; however, the scope expanded to include non-STEM subject areas as interest grew among teachers in those fields. The design of the workshops and accompanying lessons was guided by five core principles that informed their structure and delivery for participants.

- Identify AI tools applicable across a broad range of middle school courses, including platforms such as *GauGAN, Teachable Machines, Tinkercad*, and others.
- Engage and empower teachers to build confidence in using AI tools effectively for instruction.
- Encourage teachers to adapt one or more AI tools within a course of their choice to strengthen teaching and learning.
- Promote collaborative instructional design through the formation of teacher teams.
- Engage students in co-created lessons to examine and experience the instructional impact of AI-enhanced learning activities.

The computational camera approach enabled AI concepts and tools to be introduced in a discipline-agnostic manner, allowing flexible application across multiple content areas. Over the four-year duration of the workshops, participating cohorts gravitated toward four primary instructional domains: (1) Engineering and Integrated STEM, (2) English Language Arts and Social Studies, (3) Mathematics, and (4) Science. A brief discussion of each instructional area and the corresponding lesson modules developed are briefly described below.

Engineering and Integrated STEM

Two instructional lesson modules were developed within the Engineering and Integrated STEM focus area. The first lesson, *Understanding Universal System Design*, introduced students to systems thinking through the use of the GauGAN tool. The instructor employed GauGAN as an entry point for motivating students to explore the foundational concepts of Generative Adversarial Networks (GANs) and their application within system modeling. This lesson aligned with the Georgia Standard MS-ENG-TS-3, which emphasizes students' ability to examine how multiple components interact within a system model. The integration of GauGAN supported students in visualizing system components and optimizing design solutions through iterative exploration.

The second lesson, titled *Design Assistive Devices Using Pixlr and Tinkercad*, engaged students in the iterative engineering design process using digital tools. Students designed kitchen-based assistive devices intended to improve the organization of commonly used, everyday items. This lesson aligned with CSS.IDC.6–8.29, which focuses on creating digital artifacts to address real-world problems requiring resolution. Through this experience, students applied design thinking and digital modeling to develop practical, user-centered solutions.

English Language Arts (ELA) and Social Studies

Two instructional lesson examples from the ELA and Social Studies domain are presented.
The first lesson, titled *Mexican Art History and AI Image Classification*, utilizes Teachable Machine to train an image classification model that distinguishes between authentic and AI-generated artworks. Through this activity, students explore stylistic differences between two renowned Mexican artists, Diego Rivera and Frida Kahlo**.** Students analyze defining artistic features associated with each artist, then recreate original artworks inspired by their styles. These student-generated pieces are subsequently compared to historical examples to evaluate how closely the trained model recognizes and classifies the recreated works in relation to the original artists' styles. This process engages students in both art analysis and an applied understanding of AI-based image classification.

The second lesson, titled *Middle East Water Conflict*, follows a three-step inquiry-based progression**.** First, students examine three assigned source texts addressing water scarcity and resource challenges in the Middle East. Second, students formulate a written claim, supported by textual evidence, explaining how water availability contributes to regional conflict. Finally, students use Pixlr to design a visual representation that communicates key aspects of the water conflict, integrating geographic, political, and environmental perspectives. This lesson combines literacy skills, social studies content, and visual communication through digital media.

Mathematics and Science

Two Mathematics-focused lesson modules were developed. For example, one module titled *Surface Area and Volume Using Tinkercad*, engages students in finding the surface area and volume of a rectangular prism by designing and constructing a house using Tinkercad 3D modeling. Through this project-based activity, students apply geometric formulas in a hands-on digital environment that connects mathematical concepts to real-world design.

Two Science-focused lesson modules are presented. The first lesson, titled *Plant vs. Animal Cells*, is structured as a four-step learning sequence**.** First, students examine the structures, shapes, and functions of plant and animal cells. Second, students use Teachable Machine to train an AI model to distinguish between plant and animal cells based on visual features. Third, students design and create their own 3D cell models using Tinkercad**.** Finally, students test the performance of their trained AI models by classifying the student-created 3D cell models, allowing them to evaluate the AI's ability to correctly identify cell types.

The second lesson, titled *Plant Leaf Identification*, focuses on Georgia agriculture and the application of computer vision techniques for plant identification. Students first develop an understanding of image classification algorithms and their real-world applications. Students then use pre-collected leaf samples to train their own machine learning models using Teachable Machine**.** Finally, students evaluate their models by classifying additional leaf samples and comparing model predictions with known classifications. Through this lesson, students connect biological concepts with applied AI technologies used in agriculture and environmental sciences.

General Lesson Module Design

Each of the lesson modules described above resulted in visually rich and highly interactive learning artifacts**,** fostering meaningful engagement both among participants and between participants and AI tools. Prior to selecting specific AI tools for lesson implementation, participants engaged in collaborative discussions to evaluate the strengths and limitations of available tools for particular instructional applications. This process supported deliberate, evidence-based decision-making, as tool selection was guided by consensus and instructional purpose rather than convenience.

Interaction between participants and AI tools was a central feature of the lesson designs. For example, training a model using Teachable Machine required multiple iterative cycles, with a minimum of approximately fifty training iterations recommended to establish acceptable classification performance. Through repeated training cycles, the model accumulated sufficient data to improve its ability to distinguish between authentic and generated objects.

Overall, the integration of computer vision and machine learning tools provided a robust, hands-on learning platform for the middle school AI workshops. These technologies enabled participants to actively explore AI concepts through experimentation and iteration, reinforcing both conceptual understanding and practical application.

Research

Theoretical Framework

Individuals actively construct meaning based on their experiences, interpretations, and prior knowledge (Raskin, 2002). This perspective aligns with Personal Construct Theory**,** which provides a framework for understanding how individuals develop and apply personal systems of meaning to guide their thinking and actions (Kelly, 1955). The theory emphasizes that personal perspectives are not fixed but evolve as individuals engage with new experiences and challenges (Chiari, 2023).

Within the context of the AI workshops, participating teachers constructed their own understandings of AI tools and pedagogy through hands-on engagement and collaborative design. These evolving perspectives directly informed the curricular decisions teachers made while co-creating lesson modules. Personal Construct Theory offers an appropriate lens for examining how participants interpreted their experiences and exercised agency in leading the design and implementation of instructional activities, as supported by prior educational research (Pope & Denicolo, 2021; Roberts, 1999).

Science Lesson: Translucent, Transparent and Opaque

In this science lesson**,** students investigated the differences between transparent, translucent, and opaque materials by examining how light passes through each. The experimental setup included a Teachable Machine (TM) configuration, glass containers, water, milk, juice, a mixing spoon, and a light source. *Figure 1* illustrates two sample conditions: a glass containing clear water and a glass containing water mixed with milk.

During the lab activity, students systematically altered the transparency of water by adding varying amounts of milk or juice and compared these changes to the computer's ability to "see" through the liquid using Teachable Machine. Students captured images of the prepared samples using webcams and uploaded the images to TM to train a machine learning model capable of identifying different levels of translucency**.** Through multiple iterations, students refined the model to improve its classification accuracy.

Figure 1A:
Clear water

Figure 1B:
Milk water mix

Following the activity, students engaged in guided reflection through the discussion questions:

(a) What properties of the liquid helped identify it as transparent, translucent, or opaque?
(b) How accurate was Teachable Machine in classifying these properties?
(c) What modifications could improve the model's accuracy?
(d) In what other real-world applications might this type of machine learning activity be useful?

Feedback and perspective

Results from student participants (n=17) showed significant ($p < .05$) increases in students' perceptions of themselves as more active learners and active perceptions of coders and engineers. Teachers reported high levels of satisfaction with the integration of AI-based instructional strategies and noted positive impacts on student engagement and learning. Several teachers have extended the impact of the workshops by presenting their work at professional conferences, sharing evidence of successful instructional innovation. The workshops provided teachers with essential AI competencies and reusable instructional content, enabling sustained growth in their capacity to support student and community learning.

All participating teachers reported high levels of satisfaction with the use of AI tools for instruction. The science teacher noted strong student engagement, particularly as students experimented with "challenging" the Teachable Machine to distinguish among the three light-transmission conditions—transparent, translucent, and opaque. This exploratory behavior reflected both curiosity and deeper conceptual thinking.

Similarly, the social studies teacher described an activity in which students were provided with a territorial map and instructed to use specific colors to represent each region. Upon completing their maps, students compared their work with the teacher's reference model, prompting reflection on accuracy and historical understanding. Reflecting on the experience, the teacher stated, *"I feel confident introducing AI in my Social Studies classes at my school."*

Overall, teacher feedback indicated a strong level of satisfaction and confidence in integrating AI tools into classroom. More results will be presented from a 2026 June workshop at UGA.

Concluding Remarks

The AI workshops in Georgia through NSF-ITEST project had a positive impact on both teachers and students. Teachers reported that the AI tools were easy to implement in classroom settings and accessible for student use. Additionally, teachers observed higher levels of student motivation and engagement during learning activities that incorporated AI tools, compared to previous instruction that did not include these technologies.

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