ImageSTEAM: Teacher Professional Development for Integrating Visual Computing into Middle School Lessons

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Abstract

Artificial intelligence (AI) and its teaching in the K-12 grades has been championed as a vital need for the United States due to the technology's future prominence in the 21st century. However, there remain several barriers to effective AI lessons at these age groups including the broad range of interdisciplinary knowledge needed and the lack of formal training or preparation for teachers to implement these lessons. In this experience report, we present ImageSTEAM, a teacher professional development for creating lessons surrounding computer vision, machine learning, and computational photography/cameras targeted for middle school grades 6-8 classes. Teacher professional development workshops were conducted in the states of Arizona and Georgia from 2021-2023 where lessons were co-created with teachers to introduce various specific visual computing concepts while aligning to state and national standards. In addition, the use of a variety of computer vision and image processing software including custom designed Python notebooks were created as technology activities and demonstrations to be used in the classroom. Educational research showed that teachers improved their self-efficacy and outcomes for concepts in computer vision, machine learning, and artificial intelligence when participating in the program. Results from the professional development workshops highlight key opportunities and challenges in integrating this content into the standard curriculum, the benefits of a co-creation pedagogy, and the positive impact on teacher and student's learning experiences. The open-source program curriculum is available at www.imagesteam.org.

Introduction

Artificial intelligence (AI) and its applications in related fields of natural language processing and computer vision (CV) has transformed our workplaces, entertainment, healthcare, and homes. Originally limited to specific applications such as game playing and chatbots, AI technology, driven by recent advances in deep learning and neural networks, have become ubiquitous in smartphones, intelligent personal assistants such as Siri and Alexa, and social media. AI is increasingly being used in critical sectors of our society including assisting doctors and healthcare systems, underpinning our financial institutions, and driving our economy.

All these technological advances have led to renewed interest in AI education, permeating K-12 and higher education, to ensure that global citizens in the future have a strong understanding of the implications of this technology on their lives. However, the field of AI, and overlapping fields like computer vision, is an interdisciplinary potpourri of computer science, mathematics, cognitive psychology, neuroscience, and even philosophy of mind. Teaching these topics have been largely relegated to the undergraduate and graduate curriculum. Yet recently there have been calls to extend AI education for K-12 levels for remaining globally competitive.

Of particular interest to this paper is the field of visual computing that is central in the resurgence of AI. Images and videos have become a central form of communication, entertainment, and practical use in everyone's life, and the smartphone camera has become an essential accessory. Computer vision algorithms utilize AI and machine learning to help analyze and interpret image/video data including 3D reconstruction, image classification/identification, and object detection and tracking. New cameras of the future, entitled computational cameras, will feature new optics and electronics combined with enhanced, intelligent algorithms to understand more about the visual world around us.

The primary challenge of introducing AI and computer vision into K-12 levels is the lack of teachers with the proper professional training and experience to deliver such a curriculum. Most teachers will not have taken AI and visual computing courses in their undergraduate/graduate training. Further, while there may be opportunities to introduce visual computing into computer science education, integrating into core science, math, and English/Language Arts (ELA) classes takes more careful design and creativity. Yet this integration is critical to reach a broad, diverse group of students (not just students who take computer science/technology electives) where AI will impact their future lives the most.

In this experience report, we describe a program called ImageSTEAM, a series of teacher professional development (PD) workshops which developed a curriculum for middle school grades surrounding computer vision, machine learning, and computational cameras. This curriculum was co-created with middle school teachers in summer PD workshops across the states of Arizona and Georgia. A key focus of ImageSTEAM is the emphasis on visual media as a bridge technology between concepts of AI and visual computing with core science, math, and ELA state and national standards taught at this age group. This integration relies on principles from STEM and the arts or STEAM education which permeates the resulting curriculum.

In the following sections, we outline literature related to AI teacher professional development, describe our ImageSTEAM program including its pedagogy, teacher PD activities, technology experiences, and resulting curriculum, and present initial results and feedback on the program. Our ImageSTEAM curriculum and teacher PD resources are available at our website[1]. We hope this program will be utilized by a larger group of national educators and interested organizations.

Related Literature

Teacher Professional Development in AI for K-12 Education

While a nascent field, there has been a growing body of literature on the teaching of AI in the K-12 levels. The recently formed AI4K12[2] has created guidelines for teaching AI in public schools to aid integration efforts. Teacher professional development workshops have been conducted to integrate AI concepts into STEM classes for high school students (Lee and Perret 2022). For computer science teachers, a technological pedagogical content knowledge (TPACK) framework was introduced for professional training (Sun et al. 2022). Akram et al. utilized the Snap programming environment to teach about basic AI concepts in search algorithms which was introduced to teachers in two-week workshops (Akram et al. 2022). Extending beyond STEM classes, Lin and Van Brummelen conducted teacher professional development workshops where teachers co-designed curriculum that were integrated into English and Social Studies classes at the middle school level (Lin and Van Brummelen 2021). In particular, AI ethics and literacy have been championed for middle school students with the introduction of MIT's DAILy curriculum (Zhang et al. 2022). For more creative teacher PD design, Lee et al. introduced an AI book club which met online to discuss activities and readings for several weeks (Lee et al. 2022).

In addition to teacher professional development, holistic curriculum design for AI education was outlined by Chiu (2021) to contain the four aspects of content, produce, process, and praxis (Chiu 2021). While most studies focus on middle and high school education, there also has been recent work on elementary school education where AI literacy is advocated through problem-based learning and interactions with basic programming and robotics (Su and Zhong 2022).

STEAM Education

One recent educational trend is to employ the use of arts and humanities pedagogy infused into a STEM curriculum, known as STEAM education, or STEM + arts. Advocates claim that the arts and humanities help foster creativity and divergent thinking models for STEM students (Maeda 2013; Henriksen 2014; Oner et al. 2016; Cruz et al. 2021). For our particular case of using visual media, research has shown that using an integrated or interdisciplinary curriculum such as a STEM curriculum that reflects the real world, improves student learning and retention (Stohlmann, Moore, and Roehrig 2012). Interactive simulations and visual media can be used as an alternative and as supplemental tools applied to STEM education, they tend to enhance traditional learning such as standard class assignments, conventional teaching, physical laboratories, etc. (Rutten, Van Joolingen, and Van der Veen 2012).

ImageSTEAM Program

In this section, we outline our thematic focus for the ImageSTEAM curriculum on visual computing. We proceed to describe our teacher professional development structure and activities during our summer workshops. We describe the variety of technology experiences and demonstrations that participants in the program interacted with. We present some examples from the resulting curriculum. Finally we focus on educational research conducted on teacher self-efficacy and outcomes as well as larger themes and challenges that emerged from the professional development.

Thematic Focus: Visual Computing

Visual computing is a term which encompasses research surrounding computer vision and graphics as well as their intersection with artificial intelligence and machine learning. This area is fueled by the rise of computational cameras, a generalization of a regular camera which co-designs the optics, sensor electronics, and algorithmic image processing to uncover new visual information about the world than what is typically captured in a regular 2D photograph (Zhou and Nayer 2011). The algorithms to process these rich visual information draw from the AI-heavy fields of computer vision (CV) (Szeliski 2010), computer graphics (Shirley and Marschner 2009), and machine learning (ML) (Mitchell 1997). Focusing the ImageSTEAM program on computational cameras allowed students and teachers to connect more advanced topics of AI/CV/ML with fundamental visual media concepts underlying photography: what is a pixel? how is color represented? what is a camera's focus and exposure?

As a result, our program was designed to feature basic fundamental lessons in image processing, machine learning from images using neural networks and supervised learning, and computational photography applications such as high dynamic range (HDR) (Debevec and Malik 2008), panoramic image stitching, and AI-generated images using generative adversarial networks (Goodfellow et al. 2020) and diffusion-based architectures (Rombach et al. 2021). However, this core curriculum was supplemented by integration of computer vision/computational cameras into various core science, math, and ELA topics including how images are used in hurricane damage assessment, how human vision differs from computer vision, and how the authenticity of a

[1] www.imagesteam.org

[2] https://ai4k12.org/

source of information can be determined. A key focus was the use of activities that had teachers and students interact with images and visual media through technology demonstrations which we describe later in this section.

Teacher Professional Development

Our first set of workshops (one in Arizona and one in Georgia) were held in Summer 2021 as remote workshops due to restrictions from the COVID-19 pandemic. These set of workshops served as a pilot that helped inform the current teacher professional development workshops that were conducted in-person/hybrid in Summer 2022 and Summer 2023. We proceed to describe our co-creation philosophy with teachers and the workshop schedule and activities conducted. A key aspect of our teacher professional development is the testing of created lessons on a group of middle school students during the workshop, leading to iterative development of the lessons.

Curriculum Co-Design. Central to our teacher professional development is the emphasis on co-creation with middle school teachers. There has been work in the education literature showing how teachers' involvement in collaboratively designing curriculum materials (amongst each other) can be effective (Vescio, Ross, and Adams 2008). A common finding to all these teacher and curriculum development practices is that they can both positively influence teacher professional development as well as curriculum implementation (Voogt, Pieters, and Handelzalts 2016). In our program, we treated teachers as integral parts of the professional learning community along with the researchers, graduate assistants, and the students themselves (Vescio, Ross, and Adams 2008). To support the curricular design team, Binkhorst et al. see an essential role for a coach with specific tasks that help regulate the team' s interactions, alignment of goals within the team, and providing structure in the activities the team carries out (Binkhorst et al. 2015). We view the role of the researchers as providing this coaching to the teachers as we introduce them to ideas in artificial intelligence and visual computing, while the teachers are the experts who can yield insights about how to integrate these ideas effectively into the middle school curriculum.

Workshop Schedule and Activities The general structure of the workshop followed a tripartite formula: (1) introductory lessons from the research team on AI and visual computing topics; (2) Co-creation of a lesson targeting a particular standard for each teacher; (3) Deployment of the lesson with middle school students in a week-long class environment. This seemed to work well for iterative development of the lesson, as many lessons were changed or modified after their deployment based on the teachers' experiences. Workshops lasted between two to four weeks depending on the state and year where teachers participated in activities every day for 3-6 hours a day.

During the first part of the workshop, teachers were introduced to the AI concepts (data, AI, machine learning, computational cameras, neural networks, GANs), and technology experiences with tools such as Google's Teachable Machine, pixlr, NVIDIA's GauGAN, etc. In adition to the in-person/synchronous activities, the research team leveraged several online videos and tutorials hosted at the project's webpage that teachers could access at home for self-study. Teachers also observed students learning this material in a class "How Can Computers See?" where students were instructed by the research team. At the end of this first week, teachers started to co-create their lessons with the research team, incorporating AI activities and lessons along with the specific standards they wished to teach.

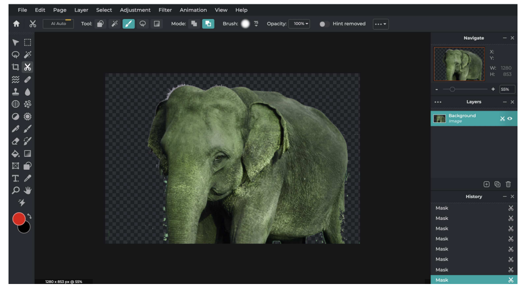

Figure 1: pixlr was a free photoediting tool that students used to perform cropping, segmentation, color and edge filtering. Illustrated in this figure is an example of the popular "AI Zoo" assignment where students edited their favorite animal images.

In the second phase of the workshop, teachers taught their initial lesson to the students in the second iteration of the "How Can Computers See?" course, aided by the research team. Teachers were given feedback on their course deployment, and worked to improve their lessons.

In the final phase of the workshop, teachers, in consultation with the project team, taught their lesson module a second time to a new set of students, as well as finalized slides, lesson summary, a teacher guide for other teachers to utilize the lesson to be disseminated online.

Technology Experiences

A key aspect of our created lessons were the use of various websites and technological tools to showcase visual computing in action for teachers and students. In particular, we aimed for material that was (1) free to use with no cost to participants; (2) software that is web-based and requires no custom installation or specialized computer specifications; (3) an emphasis on little to no coding or programming. These principles were chosen to ensure accessibility of the curriculum for students, especially those from Title I schools where technology resources may be limited. Further, the use of these tools, and their focus on generating and manipulating visual media, helped enhance the STEAM focus of our curriculum. Lessons were designed to integrate these activities directly to teach and deep students' understanding of key concepts surrounding pixels, color, image size, and machine learning.

pixlr: pixlr is a free-to-use website[3] which is similar to Adobe's Photoshop. Students used the tool to manipulate

[3] https://pixlr.com/

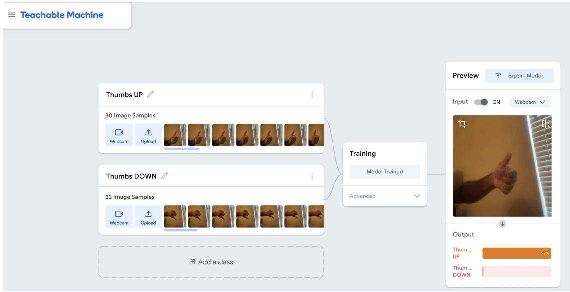

Figure 2: Google's Teachable Machine was used to train neural networks for image and audio classification. This was used in lessons ranging from American Sign Language to hurricane damage to seeing through translucent water.

images including cropping, segmentation, and color filtering. An example of the user interface can be seen in Figure 1. The tool was used for lessons including proportions and scale factors by manipulating image aspect ratios as well as ascertaining how visual allusions manipulate color perception by investigating RGB pixel values in the tool.

Google's Teachable Machine: This tool[4] lets students capture image and/or audio data, perform labeling of the data into a particular class/group, and train a classification-based neural network in a supervised learning fashion. An example of the website and its interface are displayed in Figure 2. Students leveraged this tool for a variety of activities including training a classifier for American Sign Language (utilizing the engineering design process) and uploading custom datasets such as images from post hurricane Harvey to assess flood damage. This tool was very popular for its interactive nature, and students could see concepts such as training, bias in datasets, and confidence in neural network's predictions.

Generative AI tools: Various generative AI tools were leveraged for students to create artwork or visualizations on demand. In Summer 2021 and 2022, we deployed NVIDIA's GauGAN (Park et al. 2019) which is an open-source generative modeling tool for creating visual, landscape-style images. The core technology features a neural network architecture known as a conditional generative adversarial network (GAN) which maps a stylized or cartoon image of a scene to photo-realistic results, as shown in Figure 3. Middle school students utilized this tool in several lessons in our curriculum. This ranged from activities that involved creating their dream "vacation spot" to a lesson which taught them about geological landforms leveraging the tool to a lesson which utilized the universal system model to help them improve their generated artwork through viewer feedback. Unfortunately the online free version was deprecated by NVIDIA and is currently unavailable. However, due to the release of diffusion-based art generators such as StableDiffusion[5] and integration with existing tools like pixlr, lessons in summer 2023 utilized these tools to have students visualize their favorite literature characters or design movie posters.

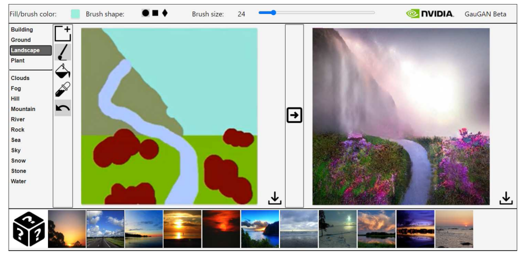

Figure 3: User interface for GauGAN tool with example participant input (left) and output (right). Students leveraged this tool for various art-making projects within the program.

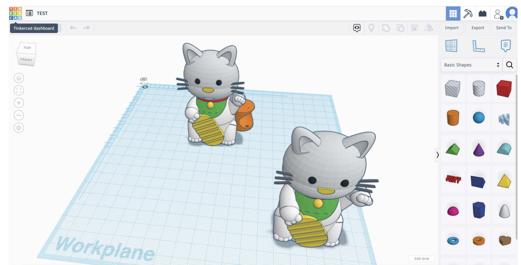

Figure 4: Students used the tool Tinkercad for 3D design. This was coupled with lessons involving designing virtual worlds for AR/VR and understanding convex/concave geometry in shapes.

Tinkercad: Tinkercad is a commonly used 3D modeling software for K12 students[6]. It features a 3D design environment where students can import or create 3D shapes, manipulate their coordinate axes, scaling, and surface properties, and compose larger environments (as shown in Figure 4). In addition, Tinkercad features procedural generation of shapes (commonly used in computer graphics and architecture applications) where visual-based coding can be used to construct complex objects in an automated fashion. There is tremendous opportunity to create lessons around Tinkercad, and the website is free to use which helps ease access issues for students. In the ImageSTEAM curriculum, Tinkercad was used to illustrate the creation of 3D virtual worlds (as a precursor to deep learning-based ways to digitize objects and environments) as well as create a dataset of convex/concave objects to train a ML model to perform recognition of a shape.

Custom Google Colab Notebooks: We have found that custom web-based Python tools for running custom computer vision applications have been beneficial for students. The research team created a custom library in Python, leveraging OpenCV and PyTorch, which can be imported directly from Github. This library was designed to ease prototyping of computer vision algorithms for educational purposes including wrapping common tasks (e.g. displaying images, cropping, color transformations) into easy to run functions that require little to no coding. This library was subsequently

[4]https://teachablemachine.withgoogle.com/

[5]https://stablediffusionweb.com/

[6]https://www.tinkercad.com/

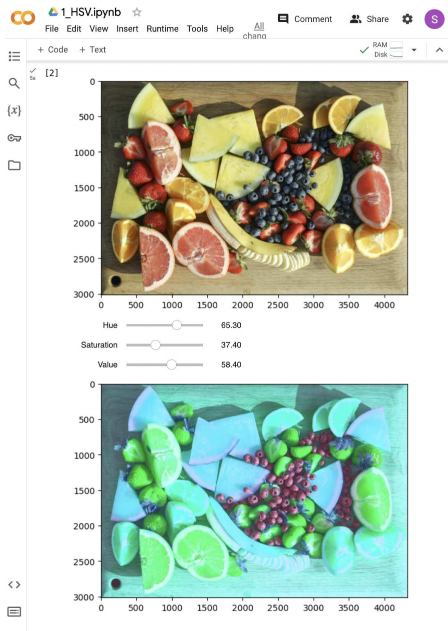

Figure 5: Custom Google Colab Python notebooks that illustrate key computer vision concepts for the ImageSTEAM curriculum.

used to create widgets and Jupyter-style Google Colab notebooks that could be demonstrated either by the teacher or the students in activities. In Figure 5, you can see an example notebook which changes the hue, saturation, and value of an image.

Results and Findings

The outcome of our summer teacher PD workshops for the development of the ImageSTEAM curriculum are outlined in this section. This includes (1) the actual co-created curriculum with lesson plans, teacher guides, lecture videos, and supplemental material; (2) Educational research surrounding teacher self-efficacy and outcomes; (3) Observations and themes from the experience of the research team.

ImageSTEAM Curriculum

Over the course of each workshop, teachers were expected to develop a single lesson that integrates computer vision, computational cameras, and/or machine learning. These lessons were organized with the following pedagogical materials:

- Lesson outline including objectives, standards alignment, and short overview of the lesson
- Video lectures and resources to be displayed in the classroom (see Figure 7)
- Lecture slides for teachers
- Teacher Guide consisting of detailed lesson plan, scripts, and other helpful resources to teach the lesson
- A "Behind the Scenes" interview with the teacher and a researcher discussing the motivation and context for the lesson
- Any associated technological demonstrations/tools for the lesson.

All of these items are available on the program's website[7] for free download and use. In particular, the creation of the content videos and "Behind the Scenes" interviews were highlighted by teachers as being innovative for a teacher professional development workshop, and teachers found a sense of ownership in the creation of their lessons. These videos were shot at a green screen studios respectively at Arizona State University and the University of Georgia, and such videos can be reused for professional development workshops in the future, aiding scalability of the program. We highlight examplar lessons which were created as part of the curriculums in the paragraphs below.

Engineering Design Process Through Sign Language Machine Learning: The objective of this lesson was that students will use their understanding of the engineering and design process to design Google's Teachable Machine to translate American Sign Language. First students are taught the tool of Teachable Machine, then introduced to the computer vision task of automatically determining common sign language words for images of students' gestures. Students then proceed to design their own Teachable Machine, collect their own data, and evaluate the performance before iterating on their design. The NGSS middle school standard the lesson aligned with is MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Making It All Fit: In this lesson, students learned about the concept of scaling and how to compute scale factors (both uniform and non-uniform). The premise of the lesson was students had to design an Ikea catalog-style picture of their room, and would use pre-made templates of common objects (furniture, lamps, etc). They would then act like architects/designers to specify the scale factors for each template that would then be placed into their room using the pixlr website. The Arizona standard this lesson aligned with was 7.G.A.1 - Solve problems involving scale drawings of geometric figures, such as computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

Predicting Hurricanes with AI and ML: Students build their own machine learning model to predict flood damaged areas due to hurricanes using satellite imagery. Students utilized a real dataset of 10,000 satellite images from after Hurricane Harvey in Texas. This lesson used Google's Teachable Machine but in a different way by uploading a real-world image dataset. Students found this lesson quite compelling in our workshop, and some students took it as a personal challenge to train all 10,000 images to train on their machines (which took a significant amount of computational time). The NGSS standards these lessons aligned with are: MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects; and MS-

[7] www.imagesteam.org

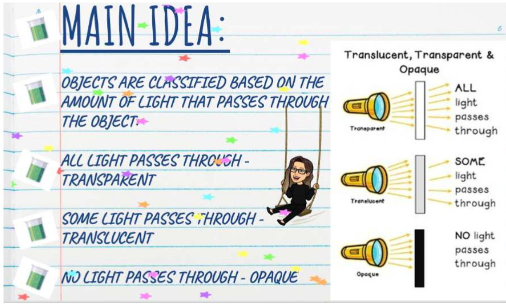

Figure 6: Translucent, Transparent and Opaque lesson co-created with a teacher from Georgia. This lesson taught concepts surrounding transmission of light and developed a hands-on activity using Teachable Machine to train a computer to see through murky water.

ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into new solutions to better meet the criteria for success.

Translucent, Transparent, and Opaque: This lesson asks students to learn the differences between translucent, transparent, and opaque materials and how light flows through each (see Figure 6). The students partake in a lab where they shift the transparency of water using juice or milk and compare the computer's ability to see through it using Google's Teachable Machine. One unique feature of this lesson is the use of interactive games in the powerpoint/lecture slides themselves, where students could click on hidden links to connect to games such as Blooklet to test conceptual knowledge. This "gamification" strategy provided for an interactive lesson. This lesson aligned with Georgia's standard S8P4.D - Develop and use a model to compare/contrast how light and sound waves are transmitted through various materials.

Themes Emerging from the Workshop

Challenges of Standards Alignment: One of the key challenges with an AI curriculum is aligning them with state standards which are required for teachers in their lessons. We noticed an interesting trend that ELA lessons actually allowed the most flexibility, as issues surrounding fake news/-media with AI-generated images and video could be easily discussed in lessons around source authentication and bias/equity in society. For science lessons, there were several instantiations of the model "AI for X" where X would range from plant identification in agriculture, hurriance and disaster response, healthcare, and geological classification. A few lessons leveraged scientific methods such as the engineering design process or the universal system method to iterate on the construction of an AI prototype/tool.

Mathematics posed a particularly difficult challenge for AI education. Math teachers expressed concern about taking time away from learning about fractions or scale factors to incorporate an experiential activity or technology demonstration. This problem did seem tied to some schools' pressure to "teach to the test" and any deviation in math lessons

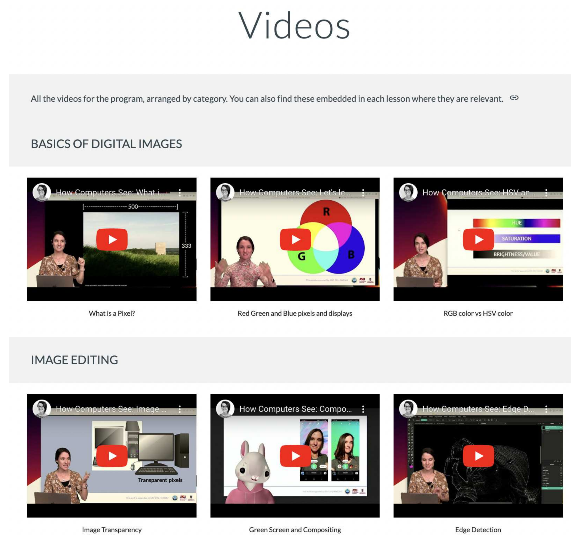

Figure 7: ImageSTEAM website containing videos and curriculum materials for teacher PD and lessons.

in particular could jeopardize test scores. Further it was difficult to follow an "AI for Math" model like in the science lessons due to middle school students base math understanding being fairly limited. However, teachers acknowledged that AI/CV lessons could help motivate students to see applications of math in everyday life.

Bias and Ethics in Artificial Intelligence: It was important that bias and ethics of AI and CV systems be brought up in the teacher PD workshops. Indeed, the AI4K12 organization has highlighted Social Impact as its fifth "Big Idea" that needs to be taught to students. As the research team presented computer vision technology, we introduced several discussions surrounding the impact of the technology and the potential bias and ethical issues that arise. For instance, lessons featuring generative adversarial and diffusion-based networks to generate realistic media also enabled discussions about how these technologies can be used to create fake news/media. In another example, teachers and students were exposed to the idea of implicit bias creeping into network training where technologies like facial recognition could perform worse on dark-skinned individuals. One student in the workshop found this ethically troubling when training Google's Teachable Machine, and proceeded to ask the entire class to contribute to the dataset to get a diverse set of individuals involved. We found that both teachers and students actually found discussions around bias and ethics less intimidating than some of the more technical topics in AI/CV/ML, and were able to share their opinions more easily based on their own personal experience.

Evaluation and Educational Research

Evaluative Feedback

In total, 43 teachers as well as 189 students participated in the ImageSTEAM program during summers 2021-2023. Independent evaluation was conducted by College Research and Evaluation Services Team (CREST) at ASU. A mixed methods approach was utilized, which included Likert-scale quantitative survey questions as well as open-ended survey questions for the teachers and students. In addition, focus groups were conducted with the teachers at each workshop. The full evaluation data reports are available on the website.

Teacher feedback was largely positive on the structure of the professional development: "I especially appreciated being able to spend the first week of the program listening to and watching the research team teach the curriculum to the students and learning about different software programs that involve computer vision and teachable machines. I thoroughly enjoyed being able to co-create lessons that allowed students to learn more about computer vision and artificial intelligence. It really helped to be able to teach the lesson during the 2nd week of the program, then make adjustments to that lesson to present to the last group of students during the 3rd week of the program." Other teachers complimented the design and use of the website in the workshop, stating "I felt the ImageSTEAM website was well-organized and easy to navigate".

The teachers' experiences were not without challenges. One teacher noted "One of the challenges was fitting an AI activity that related to the standards", and another mentioned "Technology is always hard to learn and explaining that tech is also sometimes challenging. Making sure the correct vocab words are used."

Research on Teacher PD

In addition to evaluation feedback on the teacher PD, we also conducted research studies to determine the effectiveness of our teacher PD. In recent preliminary publications (Kurz et al. 2021, 2022c,b,a; Swisher et al. 2023), we have used Personal Construct Theory (Kelly 1955) to investigate changes in teachers' perceptions with regards to artificial intelligence and computer vision after participating in the ImageSTEAM workshops. The results showed positive changes in thinking about concepts such as computer vision and artificial intelligence highlighted by changes in dendrogram structure and clustering shown in these publications.

In addition, we also evaluated our teachers' changes in self-efficacy and outcome expectancy. We used the T-STEM CT tool to measure these traits (Boulden et al. 2021). There are two subscales in this validated survey instrument designed to measure teachers' beliefs about teaching computational thinking skills to their students. Seven items measure teaching self-efficacy beliefs; the maximum score is 35, and the minimum score is 7. Six items measure teaching outcome expectancy beliefs; the maximum score is 30, and the minimum score is 6. Data are provided from the 2022 summer cohort for each subscale. Statistically significant differences cannot be validated with our small sample size ($n = 12$); therefore, we provide descriptive statistics. There was no missing data; all of the teachers completed the pre- and post-survey. The study was approved by IRB and all teachers consented.

The results were as follows, listed in mean, standard deviation, min, max $(\mu, \sigma, \min, \max)$ format. For the **self-efficiacy subscale**, the pre-survey reported $(\mu = 18.58, \sigma = 6.829, \min = 7, \max = 28)$ while the post-survey reported $(\mu = 29.5, \sigma = 5.214, \min = 18, \max = 35)$. For the **outcome expectancy subscale**, the pre-survey reported $(\mu = 20.33, \sigma = 4.755, \min = 13, \max = 30)$ and the post-survey reported $(\mu = 22.42, \sigma = 3.232, \min = 18, \max = 30)$. Our results showed an improvement in teachers' self-efficacy and outcome expectancy beliefs. The self-efficacy subscale indicated a 58.8% increase in teachers' self-efficacy beliefs regarding teaching computational thinking skills to their students. Scores improved within outcome expectancy subscale, with a much smaller increase of 10.3% from the pre- to post-survey. There was also a decrease in the standard deviation for both subscales, indicating less variance around the mean. Our results indicate that we had a greater impact on teachers' self-efficacy than teachers' outcome expectancy.

Implications for AI K12 Education

The ImageSTEAM teacher professional development and co-created curriculum adds to the existing body of literature on integrating AI into the K-12 landscape. In particular, the emphasis on visual computing and how visual media is ubiquitous in our world served as a backbone for the curriculum and its lessons, but with enough flexibility to fit into lessons ranging across middle school science, math, and some ELA topics. The activities, grounded in STEAM philosophy, aimed to have students experience AI and visual computing technology through art-making, design challenges, and creative projects.

While there was positive feedback and reflection from the summer workshops of this program, there still remains significant challenges in deploying such a curriculum in grades 6-8 curriculum. Further research is needed into the factors, attitudes, and motivations which enable teachers to integrate difficult AI topics into their lesson plans. Indeed many teachers claimed that only a top-down decision from higher administration where AI/visual computing was written into state standards would force teachers as a whole to adopt this and other AI curriculum. In addition, there is still much research needed to understand how students can absorb and increase their knowledge of AI, which is difficult to capture in our one week of lesson deployment.

Finally, the availability of easy-to-use tools is still needed for AI education. Tools like NVIDIA's GauGAN and Google's Teachable Machine are great but limited in scope, and these tools are frequently not updated or maintained beyond a few years. In contrast, custom Python notebooks developed as part of this program require significant design and implementation overhead, and would require significant paid investment to develop these notebooks further. While more of these tools will be readily available for use in K12 lesson plans and activities, there also needs to be coordinated teacher professional development to help train teachers to use these resources effectively in the classroom.

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References

Akram, B.; Yoder, S.; Tatar, C.; Boorugu, S.; Aderemi, I.; and Jiang, S. 2022. Towards an AI-Infused Interdisciplinary Curriculum for Middle-Grade Classrooms. *Proceedings of the AAAI Conference on Artificial Intelligence*, 36(11): 12681–12688.

Binkhorst, F.; Handelzalts, A.; Poortman, C. L.; and Van Joolingen, W. 2015. Understanding teacher design teams–A mixed methods approach to developing a descriptive framework. *Teaching and Teacher Education*, 51: 213–224.

Boulden, D. C.; Rachmatullah, A.; Oliver, K. M.; and Wiebe, E. 2021. Measuring in-service teacher self-efficacy for teaching computational thinking: development and validation of the T-STEM CT. *Education and Information Technologies*, 26(4): 4663–4689.

Chiu, T. K. 2021. A holistic approach to the design of artificial intelligence (AI) education for K-12 schools. *TechTrends*, 65(5): 796–807.

Cruz, J.; Bruhis, N.; Kellam, N.; and Jayasuriya, S. 2021. Student implicit epistemologies when working at the intersection of art and engineering. *International Journal of STEM Education*.

Debevec, P. E.; and Malik, J. 2008. Recovering High Dynamic Range Radiance Maps from Photographs. *ACM SIGGRAPH*, 31:1–31:10.

Goodfellow, I.; Pouget-Abadie, J.; Mirza, M.; Xu, B.; Warde-Farley, D.; Ozair, S.; Courville, A.; and Bengio, Y. 2020. Generative adversarial networks. *Communications of the ACM*, 63(11): 139–144.

Henriksen, D. 2014. Full STEAM ahead: Creativity in excellent STEM teaching practices. *The STEAM Journal*, 1(2): 15.

Kelly, G. 1955. *Personal construct psychology*. Norton.

Kurz, T.; Jayasuriya, S.; Swisher, K.; Mativo, J.; Pidaparti, R.; and Robinson, D. T. 2022a. Investigating Changes in Teachers' Perceptions about Artificial Intelligence after Virtual Professional Development. *Journal of Interactive Learning Research*, 33(4): 225–241.

Kurz, T. L.; Jayasuriya, S.; Rego, J.; Jackson, K.; Swisher, K.; Mativo, J.; Pidaparti, R.; Robinson, D.; and Collins, C. 2021. Changes in Middle School Teachers' Thinking after Engaging in Professional Development Emphasizing Computer Vision. *SITE Interactive Conference*, 329–333.

Kurz, T. L.; Jayasuriya, S.; Swisher, K.; Mativo, J.; and Pidaparti, R. 2022b. Researching the Impact of Artificial Intelligence Curriculum on Teachers' Thinking. *SITE Interactive Conference*, 336–339.

Kurz, T. L.; Jayasuriya, S.; Swisher, K.; Mativo, J.; Pidaparti, R.; and Robinson, D. 2022c. Mapping In-Service Teachers' Thinking about Artificial Intelligence Before and After Professional Development. *Proceedings of Innovate Journal: AACE 2022*, 125–135.

Lee, I.; and Perret, B. 2022. Preparing High School Teachers to Integrate AI Methods into STEM Classrooms. *The 12th Symposium on Educational Advances in Artificial Intelligence*.

Lee, I.; Zhang, H.; Moore, K.; Zhou, X.; Perret, B.; Cheng, Y.; Zheng, R.; and Pu, G. 2022. AI Book Club: An Innovative Professional Development Model for AI Education. In *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education - Volume 1*, SIGCSE 2022, 202–208. New York, NY, USA: Association for Computing Machinery. ISBN 9781450390705.

Lin, P.; and Van Brummelen, J. 2021. Engaging teachers to Co-design integrated AI curriculum for K-12 classrooms. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–12.

Maeda, J. 2013. Stem + art= steam. *The STEAM Journal*, 1(1): 34.

Mitchell, T. M. 1997. Machine learning. *Burr Ridge, IL: McGraw Hill*, 45(37): 870–877.

Oner, A. T.; Nite, S. B.; Capraro, R. M.; and Capraro, M. M. 2016. From STEM to STEAM: Students' beliefs about the use of their creativity. *The STEAM Journal*, 2(2): 6.

Park, T.; Liu, M.-Y.; Wang, T.-C.; and Zhu, J.-Y. 2019. Semantic Image Synthesis with Spatially-Adaptive Normalization. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*.

Rombach, R.; Blattmann, A.; Lorenz, D.; Esser, P.; and Ommer, B. 2021. High-Resolution Image Synthesis with Latent Diffusion Models. arXiv:2112.10752.

Rutten, N.; Van Joolingen, W. R.; and Van der Veen, J. T. 2012. The learning effects of computer simulations in science education. *Computers & Education*, 58(1): 136–153.

Shirley, P.; and Marschner, S. 2009. *Fundamentals of Computer Graphics*. USA: A. K. Peters, Ltd., 3rd edition. ISBN 1568814690.

Stohlmann, M.; Moore, T. J.; and Roehrig, G. H. 2012. Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER)*, 2(1): 4.

Su, J.; and Zhong, Y. 2022. Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions. *Computers and Education: Artificial Intelligence*, 3: 100072.

Sun, J.; Ma, H.; Zeng, Y.; Han, D.; and Jin, Y. 2022. Promoting the AI teaching competency of K-12 computer science teachers: A TPACK-based professional development approach. *Education and Information Technologies*, 1–25.

Swisher, K.; Kurz, T.; Jayasuriya, S.; Covert, J.; Mativo, J.; Pidaparti, R.; and Robinson, D. T. 2023. Middle School Teachers' Perceptions of Computer Vision. In *Society for Information Technology & Teacher Education International Conference*, 2283–2288. Association for the Advancement of Computing in Education (AACE).

Szeliski, R. 2010. *Computer vision: algorithms and applications*. Springer Science & Business Media.

Vescio, V.; Ross, D.; and Adams, A. 2008. A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education*, 24(1): 80–91.

Voogt, J. M.; Pieters, J. M.; and Handelzalts, A. 2016. Teacher collaboration in curriculum design teams: Effects, mechanisms, and conditions. *Educational Research and Evaluation*, 22(3-4): 121–140.

Zhang, H.; Lee, I.; Ali, S.; DiPaola, D.; Cheng, Y.; and Breazeal, C. 2022. Integrating Ethics and Career Futures with Technical Learning to Promote AI Literacy for Middle School Students: An Exploratory Study. *International Journal of Artificial Intelligence in Education*, 1–35.

Zhou, C.; and Nayer, S. 2011. Computational Cameras: Convergence of Optics and Processing. *IEEE Transactions on Image Processing*, 20(12): 3322–3340.