Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46549

# BOARD # 396: NSF AISL: Incorporating Linear Algebra in An AI LiteracyCurriculum in Informal and Formal Learning Settings

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# NSF AISL: Incorporating Linear Algebra in An AI Literacy Curriculum in Informal and Formal Learning Settings


## Abstract

This paper summarizes the progress made since fall 2023 on a research grant funded through the National Science Foundation (NSF) DRL: Collaborative Research: Cultivating Tomorrow's Innovators Through Exploring Planetary Images with Artificial Intelligence. The major goals of the NSF project to be accomplished over three years are: (1) to design, develop and test a sequence of lessons aiming to teach AI/ML concepts to high school aged youth and the public at large by using planetary images; and (2) to use a mixed-methods design to investigate the impact of the sequence of lessons developed for AI literacy on high school youth's STEM learning and identity. This paper summarizes the preliminary findings focusing on the linear algebra lessons developed for high school aged youth as an essential component of our AI literacy curriculum.


## Introduction

The rapid permeation of AI into nearly all walks of life and every profession calls for innovative approaches of promoting public AI literacy and education in all settings [1]. In the past few years, with support from a previous NASA grant and the current NSF AISL grant (2023-2026), we have been working on expanding the appreciation of both planetary images and also new technologies in AI/ML among high school youth and the public at large through an interdisciplinary approach with the spirit of experimentation [2]. Before the start of the NSF-funded *Planet+AI*, we mainly used an application approach to introduce the essential three elements of AI/ML (data, algorithms and compute), for example, engaging youth in using given colab notebooks on open-source text-to-image and super resolution models with NASA's HiRISE images to generate synthetic images of Martian landscapes and model Mars surface features. Some of the youth's projects were exhibited at the CVPR (a flagship AI conference). The feedback showed that the youth were very curious about what's behind the code. It seems quite natural that some of them started to ask questions and tried to tinker with code themselves.

During the first year of the NSF project, we incorporated a mixture of out-of-school and online activities and reached out to high school youth through online public webinar series, public lecture/workshop series, newsletters, and exhibits. Some of the youth's projects have been on exhibit since March 2024 at the American Museum of Science and Energy. We conducted the Planet+AI summer program in 2024 in three weeks- how to use Google colab notebooks, Python basics with matrix arithmetic and image processing were introduced in week 1, and statistics for AI/ML was the focus in week 2; the goal of the first two weeks was to get participants prepared for the third week on AI/ML, particularly neural networks [3]. Our public lecture/workshop series has been focusing on answering the participant's questions. We found out that after the

summer program in 2024, we got more and more questions involving basic concepts in linear algebra, for example, dot products used in convolutional neural networks. Some program alumni from our NASA-funded projects asked us to incorporate more linear algebra topics and informed us that their own school in the Bay Area has already offered a linear algebra course.

**Incorporating Linear Algebra in an AI Literacy Curriculum at the Request of Youth**

Written reflections from our program alumni and classroom observations from the 3-week summer program in 2024 show that (1) high school aged youth learnt to use Google Colab notebooks very fast and appreciated both using emerging AI/ML algorithms to generate images, videos and texts, and also applying AI/ML models in solving real-world problems; (2) they considered that concepts and notations in neural networks are hard to understand and do not connect with their prior knowledge; and (3) they appreciated the practical relevance of linear algebra which helps understand neural networks in AI/ML, and would welcome the opportunity to learn linear algebra with Python programming for AI/ML. Clearly, linear algebra plays a major role in AI/ML, and there's a need among high school aged youth that they want to understand more about what is behind the code. In order to meet our participating youth's needs, we have been working on incorporating linear algebra lessons through an interdisciplinary approach in our AI literacy curriculum; and our focus has been tailoring content to youth's developmental stage.

We recognized that teaching high school aged youth linear algebra is different from teaching adults. In order to provide meaningful and age-appropriate linear algebra lessons, we introduced basic linear algebra concepts in meaningful contexts: in the context of a high dimensional water dataset the youth created under our guidance, and also in the context of 3D reconstruction of rocks and outcrops from our recent field trip to Norway, and also from other planets in the solar system. During the summer 2024, under our guidance, our program alumni and two participants in the summer program collected drinking water samples, did chemistry work at the lab, participated in all the measurement process with the ICP-MS machine, did the data reduction and got their own high-dimensional elemental concentration dataset in drinking water samples. One of the goals of our linear algebra lessons is to apply PCA with this high-dimensional water dataset. We also introduced our recent field trip to Norway. We brought back our rock samples, photos of outcrops in the field. Another goal of our linear algebra lessons is to apply linear transformations in creating 3D reconstruction models with our rock samples, particularly porphyry, a very beautiful piece of volcanic rock in Norway.

With open-ended research questions on hand and these goals in mind, we focus on the linear algebra concepts: vectors, matrices, linear transformations, change of basis, eigenvalues and eigenvectors. We provided a booklet titled *Linear Algebra for High Dimensional Water Data and 3D Reconstruction of Porphyry* for our linear algebra lessons [4]. We also provided

supplementary colab notebooks with all colab notebooks for all the examples, diagrams, exercises and solutions. In order to avoid cognitive overload for high school aged youth, we introduced each linear algebra concept from both numeric and geometric perspectives with plenty of examples and visualizations with the applications in PCA and 3D reconstruction, and we only introduced only those important ideas which are crucial for understanding AI/ML. We also provided engaging datasets for linear algebra for AI literacy lessons, including

Feedback from our participants on our linear algebra for AI literacy lessons showed that linear algebra concepts and notations helped them understand neural networks and enabled them to tinker with the code within the given colab notebooks themselves. They felt empowered through learning solid and foundational knowledge.

**Future Work**

We plan to teach this linear algebra component in the first week of our incoming summer program in 2025. The initial research result will be used to develop the qualitative methods for the next phase of the research project. Particularly, we intend to investigate what is the impact of our linear algebra for AI literacy lessons upon developing youth's agile mindset, ability to adapt and improvise through tinkering.

**Acknowledgments**

This material is based upon work supported by the National Science Foundation under Grant No. DRL-2314155. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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