Exploring Artificial Intelligence in English Language Arts with StoryQ

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Abstract

Exploring Artificial Intelligence (AI) in English Language Arts (ELA) with StoryQ is a 10-hour curriculum module designed for high school ELA classes. The module introduces students to fundamental AI concepts and essential machine learning workflow using StoryQ, a web-based GUI environment for Grades 6-12 learners. In this module, students work with unstructured text data and learn to train, test, and improve text classification models such as intent recognition, clickbait filter, and sentiment analysis. As they interact with machine-learning language models deeply, students also gain a nuanced understanding of language and how to wield it, not just as a data structure, but as a tool in our human-human encounters as well. The current version contains eight lessons, all delivered through a full-featured online learning and teaching platform. Computers and Internet access are required to implement the module. The module was piloted in an ELA class in the Spring of 2022, and the student learning outcomes were positive. The module is currently undergoing revision and will be further tested and improved in Fall 2022.

Background

Artificial Intelligence (AI) is transforming numerous industries and generating enormous wealth. However, the advancement in AI is reshaping the workforce, impacting people whose jobs can be replaced or redefined by AI systems. The wealth generated by AI advancement is unevenly distributed across different demographic groups, exacerbating existing inequities in society. Inequalities arising from current AI development are partially rooted in the unequal access to AI educational opportunities.

K-12 is the critical stage for young people to develop foundational knowledge and interest in AI-related careers. At minimum, students need to understand that the current approach to AI development is based on machine learning (ML) from data and that data needs to be structured in ways such that machines can learn meaningful patterns (Touretzky et al., 2019). Ultimately, students should understand the roles and responsibilities of AI developers and potential pathways for their own participation in AI development.

However, in the current school curriculum, opportunities to learn AI concepts and practices are scarce. Computer science (CS) courses, where AI content is considered a natural fit, are only offered in some U.S. high schools. They also have persistent diversity issues (Code.org et al., 2021), mainly because the focus of CS is typically on aspects that rely on advanced math rather than an interdisciplinary approach that would create opportunities for engagement among a more diverse student population. Furthermore, most CS courses do not include an AI unit. Only recently, research groups have started to develop and research AI teaching strategies at the K-12 level (e.g., Glazewski et al., 2022; Lee et al., 2021), and curriculum providers have developed AI content as an optional unit (e.g., Code.org n.d.).

But AI education can extend beyond CS courses. AI is a highly interdisciplinary field. It builds on mathematical foundations and relies on disciplinary knowledge about the type of intelligence to simulate. Many AI innovations stem from the attempt to solve problems in subject domains outside CS. In the workplace, it is very common for non-CS professionals to learn and apply AI knowledge and skills and collaborate with computer scientists to solve problems in their domains. In the same way, AI education can happen in a variety of settings where the problems of interest call for AI solutions.

Integrating foundational AI education into disciplinary studies promises to transform AI education and reach students most underrepresented and underserved in the field. The key to this approach is to situate student learning in scenarios where disciplinary insights are critical for AI development, and AI applications give rise to new disciplinary practices.

To bring this interdisciplinary learning vision to life, we have developed a 10-hour curriculum module, Exploring *Artificial Intelligence (AI) in English Language Arts (ELA) with StoryQ*, for high school ELA classes. The module introduces students to fundamental AI concepts and essential machine learning workflow using StoryQ, a web-based GUI environment for Grades 6-12 learners.

AI Concepts Addressed in the Module

This module addresses a subset of the Big Ideas in AI developed by the Artificial Intelligence (AI) for K-12 initiative (AI4K12.org n.d.):

- Big Idea #2. Representation & Reasoning: 1) Representations are data structures; reasoning methods are algorithms. 2) Representations support reasoning; reasoning methods operate on representations. 3) The two major types of knowledge representations are symbolic and numerical representations. 4) "Knowing" something means the ability to both represent it and reason with it. 5) Agents are considered intelligent if they employ a non-trivial sense-deliberate-act cycle to make progress toward achieving their goals.
- Big Idea #3. Learning: 1) Machine learning allows a computer to acquire behaviors without people explicitly programming those behaviors. 2) Learning new behaviors results from changes the learning algorithm makes to the internal representations of a reasoning model, such as a decision tree or a neural network. 3) Large amounts of training data are required to narrow down the learning algorithm's choices when the reasoning model is capable of a great variety of behaviors. 4) The reasoning model constructed by the machine learning algorithm can be applied to new data to solve problems or make decisions.
- Big Idea #4. Natural Interaction: 1) Computers can use natural language to communicate factual information, but struggle to understand nonliteral modes of expression such as metaphor, imagery, humor, and sarcasm. 2) Computers can recognize but not experience emotions. Appropriate responses to emotions must be programmed by humans.
- Big Idea #5. Societal Impact: AI can impact society in both positive and negative ways. AI technologies are changing the ways we work, travel, communicate, and care for each other. But we must be mindful of the harms that can potentially occur. For example, biases in the data used to train an AI system could lead to some people being less well served than others. Thus, it is important to discuss the impacts that AI is having on our society and develop criteria for the ethical design and deployment of AI-based systems.

StoryQ: A Web-Based Machine Learning and Text Mining Tool

This module uses StoryQ, a code-free web-based machine learning and text mining tool as the primary learning tool. While many tools exist for professional NLP work (e.g., R and Python packages), tools for learning in this domain have been very limited, especially for younger learners with inadequate math and CS foundations. One such example is Machine Learning for Kids (Lane n.d.) modeling environment, which offers a tool for young learners to train text classification models. While adequate as a brief introduction, MLK's tool does not offer ways for learners to understand the inner workings of models.

The StoryQ app, a web-based machine learning and text mining tool that allows young learners (grades 6-12) to engage in machine learning practices and work with unstructured text data without coding. StoryQ features dynamically linked data representations that promote meaningful inquiries across tables, graphs, and texts—a unique user experience that makes machine learning models transparent, explainable, and engaging. Students can use StoryQ to train, test, and troubleshoot text classification models using both standard feature extractors (e.g., N-grams) and special feature extraction tools and visualizations designed to support young learners and non-computing teachers. Below we showcase a few examples of how StoryQ supports the learning of ML concepts.

Representation: Feature Extraction

StoryQ visualizes how text is represented as features. Figure 1 shows that when a unigram (single word) extraction method is applied to training data, some words such as "great" and "try" are extracted as a list of features, while other words, punctuation, and emojis are removed due to certain inclusion criteria. This feature list is the representation of the original text. Although it is not as readable for humans, it captures the meanings underlying the target label (in this case, words like "great" indicate positive sentiment).

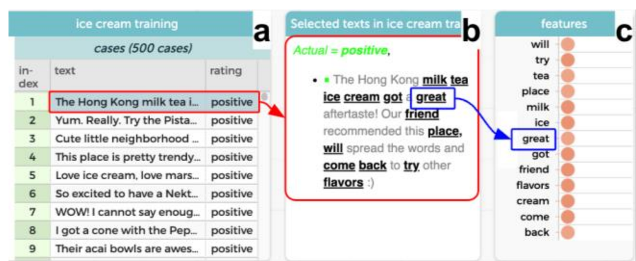

Figure 1: StoryQ visualizes features extracted from any document.

Representation: Feature Space

StoryQ extracts features from all documents (Figure 2.a) and compiles them into one feature table (a.k.a. feature space) and summarizes their frequencies associated with each label (Figure 2.b). Students can select any feature (e.g., the word "great") in the feature table and examine how the feature is used in each document (Figure 2.c) and how the feature is distributed across the two labels (Figure 2.d). This linking between the data, feature table, and feature distribution graph allows students to gain a deep understanding of how models represent knowledge and the inevitable loss of meanings as perceived by humans.

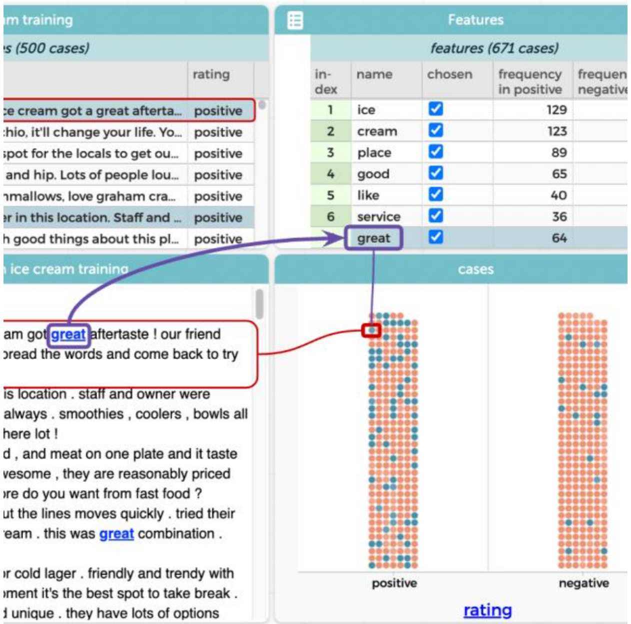

Figure 2: StoryQ generates a feature table that is dynamically linked with training data and feature distribution graph.

Machine Learning: Feature Weights

StoryQ allows learners to step through an ML algorithm and observe how the internal representation of a model (i.e., feature weights) changes as the algorithm iteratively searches for better model performance. Figure 3 shows all features as points mapped on a weight scale. As the algorithm proceeds through more iterations, the feature weights become more spread out. For example, features "like" and "great" start with weights of -0.01 and 0.05, quite close to each other, and eventually move far apart: -0.24 and 0.46, respectively. This interactive visualization offers students an intuitive way to grasp the inner workings of ML algorithms.

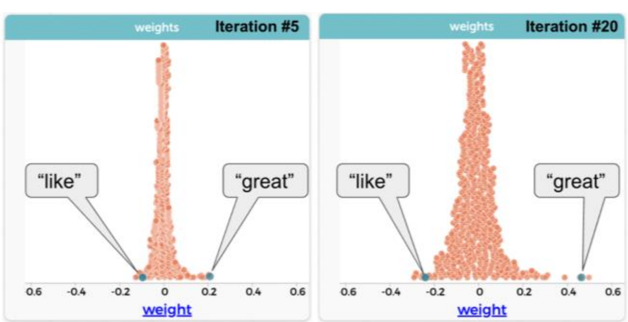

Figure 3: StoryQ visualizes how feature weights change as ML algorithm runs through iterations.

Machine Learning: Model Performance

Similarly, students can see how model performance changes over iterations. Figure 4 shows a confusion matrix of documents correctly or incorrectly predicted by the model. As the ML algorithm runs, the model becomes more accurate with a higher level of "confidence" for the majority of documents.

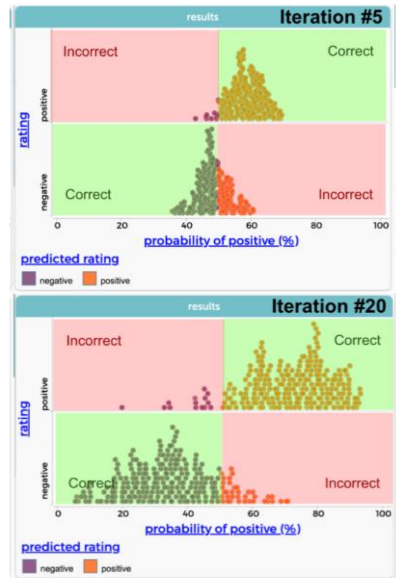

Figure 4. StoryQ visualizes how model performance changes as the ML algorithm runs through iterations.

Reasoning

StoryQ offers a visual way for students to grasp how models make predictions using the knowledge representation (i.e., machine-learned feature weights). Figure 5 shows how a sentiment analysis model reasons about two customer reviews, weighing and balancing evidence for a positive versus negative classification. Each review is represented as a bar graph where bar lengths represent feature weights. Bars extending to the right pull the prediction to the positive side and the bars extending to the left pull to the negative side.

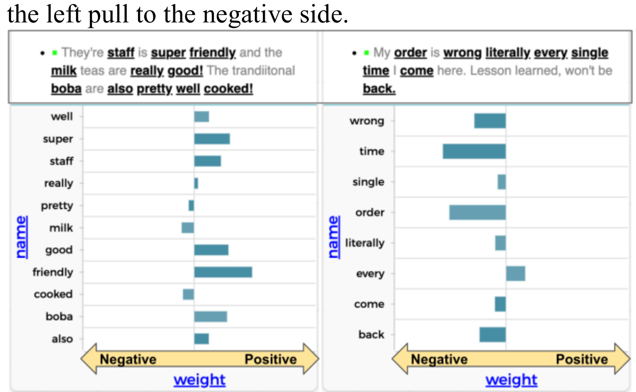

Figure 5. StoryQ visualizes model reasoning as bar graphs.

Module Overview

In this eight-lesson module, students embark on a journey to make sense of how creating artificial intelligence using machine learning tools and techniques requires a strong command of English language arts skills. Students build on their knowledge of the English language to analyze the ways humans use language and to determine strategies for sorting text examples into discrete categories. Using the StoryQ app, students examine pre-created text classification models (e.g., if a light should be turned on or off depending on the command) and seek to discover which features the model was trained to respond to. They also learn how to extract their own features, train their own model, and then use graphical representations to analyze the success of the model. Students also iteratively improve their models by analyzing the error cases to see what was overlooked or which features may have been ambiguous. Along the way, students build their confidence in developing AI and learn that the future of AI depends on people with myriad skillsets, not just on those who seek to become coders.

Activity 1: Introduction to Artificial Intelligence

Students consider a wide range of artificial intelligence (AI) applications and their impacts by drawing on their own experiences and viewing curated documentary video clips. They learn that AI is the capability of a machine to imitate intelligent human behavior and recognize that AI-powered technologies are already everywhere. By the end of the lesson, students should be able to define AI, identify examples of AI, analyze the impacts of AI, and be ready to dive into the making of AI.

Activity 2: How to Model Natural Languages?

Natural language is filled with uncertainty and ambiguity, and humans interpret language intuitively using probability (e.g., "I'm 90% sure he's joking"). Students learn how text classification mirrors this process when it takes the text and predicts its meaning in terms of probability. They also investigate a model that attempts to predict if a person wants a light to be on or off given a written command.

Activity 3: How Do Humans Classify Text?

Students discover that text has many different attributes that can be of interest for building classification models, and that each attribute can have one or more associated features that can be explicit or implicit in the text. Students then practice coming up with features that can sort the text into two categories, as they build a foundation for recognizing that a computer needs careful direction on how to analyze noisy data.

Activity 4: Machine Learning with Alien Language

Students are introduced to machine learning terms, concepts, and practices as they analyze, build and refine a model to interpret the moods in a fictitious alien language. This parallels the process machine learning algorithms use to make sense of the English language. In machine learning, a program determines the weights of different features within the text to create a predictive model for labeling future text.

Activity 5: Sentiment Analysis

Companies can receive hundreds of reviews and need a way to sort them to determine how their company is performing and to elicit themes to determine what aspect of their business to improve. In this lesson, students write, read, and explore a large collection of reviews about shops around North America. They build on the skills developed in earlier lessons to help them consider which features are important in creating these sorting algorithms.

Activity 6: Feature and Models

Words can be used in multiple ways, depending on the context. For example, how might a reviewer use the word "great"? Would they be more likely to say, "The ice cream was great!" or "I had high hopes, but this experience was a great disappointment"? In this lesson, students extract and analyze features as they identify how words are used in reviews and consider what makes a successful classification model.

Activity 7: All the Words as Features

Students build a unigram model, which is when the computer looks for words that appear multiple times, and combined with the given actual sentiment, "learns" if each word is more likely to appear in positive or negative reviews. Behind the scenes, the computer then experiments with weights for each of these words until it comes up with a model that best categorizes the provided data (as covered in Activity 4). Students use the results from their model to analyze the features of reviews. They build graphs to visualize which words have the strongest weights for classifying the reviews, and then look to specific examples to see these words in use.

Activity 8: Who Creates AI?

In this culminating lesson, students take a step back to look at the history of AI, providing more background on this illustrious field. Students then look forward, examining their own place in the changing world. Students first hypothesize about how AI may influence their future, and then watch short videos that give examples of how AI is changing the workforce. Throughout this lesson, the goal is to forefront the students, and to help them see themselves as capable actors in this world of AI.

Setup and Resources Needed

The current version contains eight lessons, all delivered through a full-featured online learning and teaching platform. The module has two editions, one for students and the other for teachers. The student edition integrates all multimedia elements in one single stream with a layout designed to minimize extraneous cognitive load and for various types of devices that students may use. The StoryQ app is embedded in the curriculum pages and autosaves students' work. The teacher edition parallels the student version but includes the purpose of the lesson for teachers, background knowledge, just-in-time teaching tips (e.g., grouping ideas or scaffolding questions), and exemplar answers. Our workshop teachers found that this edition helped them to see how they might best implement the materials.

Computers and Internet access are required to implement the module. The platform is compliant with accessibility WCAG 2.0 standards in most respects, offering an equitable learning experience for students with special needs and suboptimal computer devices. To use the module, teachers need to create a teacher account on the platform and add their students to their classes.

Implementation Results

We piloted this module in the spring of 2022 with 28 students in a journalism class in a public high school in Maryland. This class had 28 diverse youths (19 female and 9 male; 16 African American, 6 Latinx, 6 White; 3 sophomores, 9 juniors, and 16 seniors). Most students were college-bound. Nineteen students responded to an end-of-module feedback form. The large majority of them (13 of 19 respondents) rated the module as "awesome" or "pretty good." Fourteen students described what they liked about the module. Half of them appreciated the interactive learning tool (StoryQ), which allowed them to experiment extensively with models. Almost a third of them thought the module was very informative. Analysis of the pre-/post-knowledge assessments showed that the students' understandings had shifted from seeing AI as a robot or helper to conceptualizing AI as a system built to mimic human intelligence. They also demonstrated an understanding of key ML concepts, including data, features, and models. In addition, analysis of student work within the module showed that the students 1) demonstrated various patterns of iterative model development, including incremental, filter-based, and radical feature creation; 2) engaged in complex reasoning about language use in diverse contexts in trial and error, 3) leveraged multiple data representations when applying mathematical and computational techniques.

The module is currently undergoing revision and will be further tested and improved in Fall 2022.

Acknowledgments

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