AI Lesson Design & Implementation in the Biology Classroom

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Background

Transdisciplinary summer research in the application of biologically-inspired computing systems to cancer detection provided contextual background for development of a series of 10 lessons integrating artificial intelligence (AI) and computer science content knowledge with both state-specific and NGSS high school biology standards.

Real-World Problem

- Only 40% of colorectal cancers (CRC) are detected at an early stage.
- Traditional imaging techniques during clinical exam have a high miss rate, with only 59 – 84% of cancerous lesions distinguished from non-cancerous polyps.
- Early detection of CRC is associated with a good prognosis: >90% 5-year survival rate.[1]

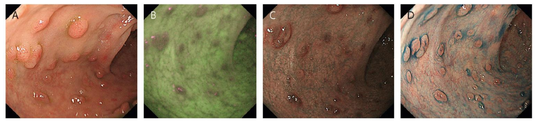


FIGURE 1 – Ignjatovic, et al, 2011.
Endoscope images of colon polyps obtained using various techniques.

Research Focus: AI-Assisted Cancer Detection

- Coupling a novel imaging technique, excitation-scanning hyperspectral imaging, with an AI model trained to distinguish normal from lesional tissue during clinical examination (endoscopy).

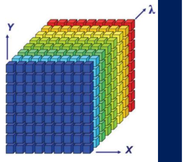


FIGURE 2 – Garini, et al, 2006.
Description of spectral image dataset.

- Normal and lesional tissue samples from patients with CRC were evaluated with the novel imaging technique to create a spectral image database for use in subsequent training of an AI model.[3]

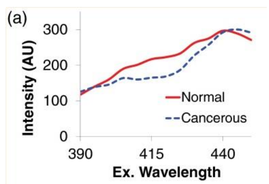
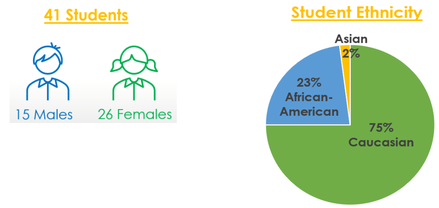


FIGURE 3 – Leavesley, et al, 2016.
Fluorescence excitation scan normal tissue (solid red line) and cancerous tissue (dashed blue line) create a "spectral signature."

Introduction

School & Course Context

9th Grade Honors Biology



- Large, suburban high school with 1100 students, equally distributed across grades 9 – 12.
- Title I school, with 26% economically disadvantaged students
- Follow block scheduling with semester-long courses.

Goals of AI-Integrated Lesson Sequence

Primary Goals

Students will:

1. examine how biology has influenced computer science & how computer science/engineering have influenced the field of biology.
2. use projects & inquiry-based lessons to understand the emerging field of AI including learning key terminology, examining computing principles relevant to AI's functioning, and investigating biologically relevant applications of AI.
3. examine use of imaging in diverse contexts as well as the technology behind capturing and storing digital images.
4. understand the properties of & role of light in the function of both biological systems & technological tools.

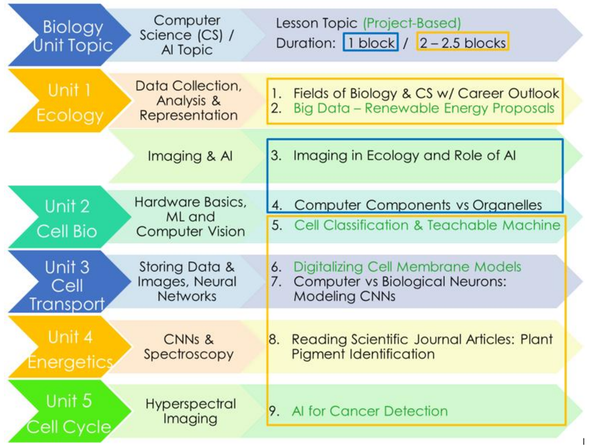
Secondary Goals

Students will:

1. strengthen basic technology skills by using a range of software applications.
2. use NGSS science and engineering practices.

Methods

Integrated AI and Biology Curriculum Lesson Sequence



- Lessons followed a 5E format.
- Implemented weekly or every 2 weeks.
- Sequence was progressive: lessons 1 – 4 provided foundational knowledge, lessons 5 – 7 were deepening lessons, and lessons 8 – 9 challenged and extended student learning.

Goal #	1	2	3	4
Lessons Addressing Primary Goal	1, 2, 3, 5, 7	2, 3, 5, 6, 7, 8, 9	3, 5, 6, 9	3, 6, 8, 9
Lessons Addressing Secondary Goal	1, 2, 3, 5, 6	All Lessons		

Results

- Change of students' biology knowledge was not significant.
- Students' AI knowledge showed a statistically significant improvement at the end of the lessons.

Paired Sample T-test		Mean	N	Std. Deviation	*t*	*p*
Pair 1	**AI Pre-Test**	7.1207	29	1.79610	**-6.48**	**<.001***
	AI Post-Test	8.8103	29	1.94300		
Pair 2	Bio Pre-Test	2.2069	29	1.1626	.424	.675
	Bio Post-Test	2.0690	29	1.39977		

Conclusions

Student Feedback
26 students provided a reflection at the end of 4th quarter.

***Factors with potential negative Impact on student responses*:**
- Reflections were collected several weeks after the AI lessons concluded.
- Timing of the reflection was at the end of the school year and right before exams.

Potential benefit of student reflection timing:
- Responses may provide a more accurate reflection of longer-term retention and insight into what components of the lesson sequence were most impactful for students.

Student reflections reported the following:
- an increased understanding of how computers store information, especially image data.
- the prevalence and uses of AI , including that "AI can be used to solve problems."
- the necessity of "training" AI models and the "hierarchy" of AI, distinguishing between Machine Learning and Deep Learning.
- enjoyment in developing and sharing presentations, physically modeling an artificial neural network, comparing biological and artificial neurons, as well as training and testing Teachable Machine models.
- enjoyed all projects even though the concepts were challenging.

Future Directions
- Design and implementation of a proficiency scale for AI topics.
- Creation of student portfolio for AI projects.
- Increased teacher-student feedback on final lesson products.

Acknowledgement

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Bibliography

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