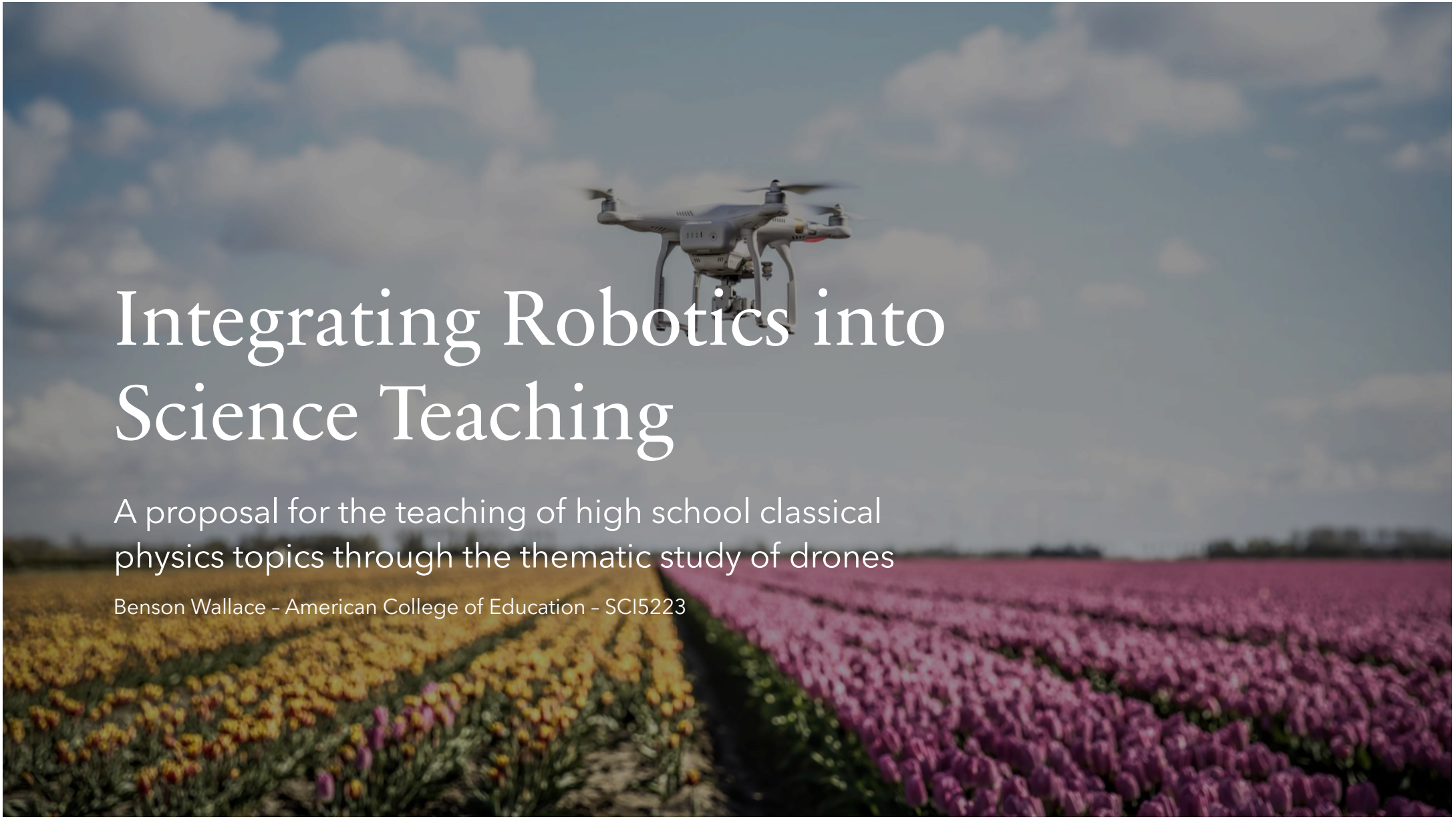
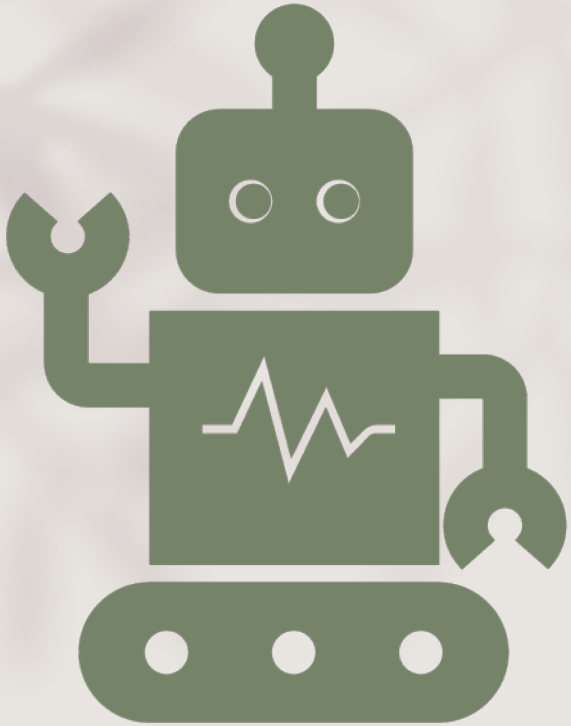


Integrating Robotics into Science Teaching

A proposal for the teaching of high school classical physics topics through the thematic study of drones

Benson Wallace – American College of Education – SCI5223



Introduction

- Use of educational robotics has increased exponentially since the turn of the century (Angel-Fernandez and Vincze, 2018)
- Students' "E-ticket" to future job market (Costa, 2017, p. 32)
- Autonomous drones are an emerging branch of robotics (Miah, 2020)

Why physics and drones?

Well suited to introducing middle school students to physics concepts in a hands-on and engaging manner (Wong, 2019)

Facilitates teaching of many advanced mechanics topics in an integrated and project-based manner, and gives students a taste of near-future tertiary study major options (Preble, 2015)

Drones and integrated STEM Education

Frameworks for integration

Concept A vs Concept B (Ćosić & Božić, 2021)

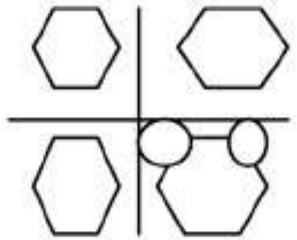
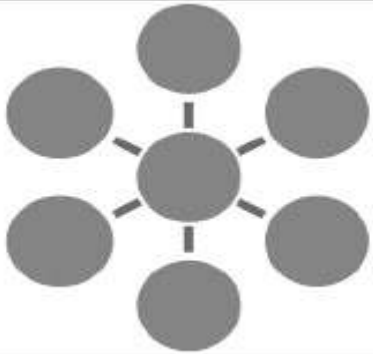
Concept A – "education about drones" (p. 161) - learning about the design, construction and operation of drones

Concept B – "education by drones" (p. 161) – use of drones to facilitate data collection for other fields of study

A connected web of physics topics

Figure 1

Connected and Webbed Models of Integrated Curriculum

 Connected	Topics within a discipline	Key concepts are connected, leading to the review, re-conceptualization and assimilation of ideas within a discipline
 Webbed	Thematic teaching, using a theme as a base for instruction in many disciplines	Motivating for students; helps students see connections between ideas

Note. Adapted from Fogarty's continuum of integrated education, as cited in Anderson (2013).

Old ideas, new technology

Figure 2
Example of a Thematic Pre-University Physics Curriculum from 1980s Holland

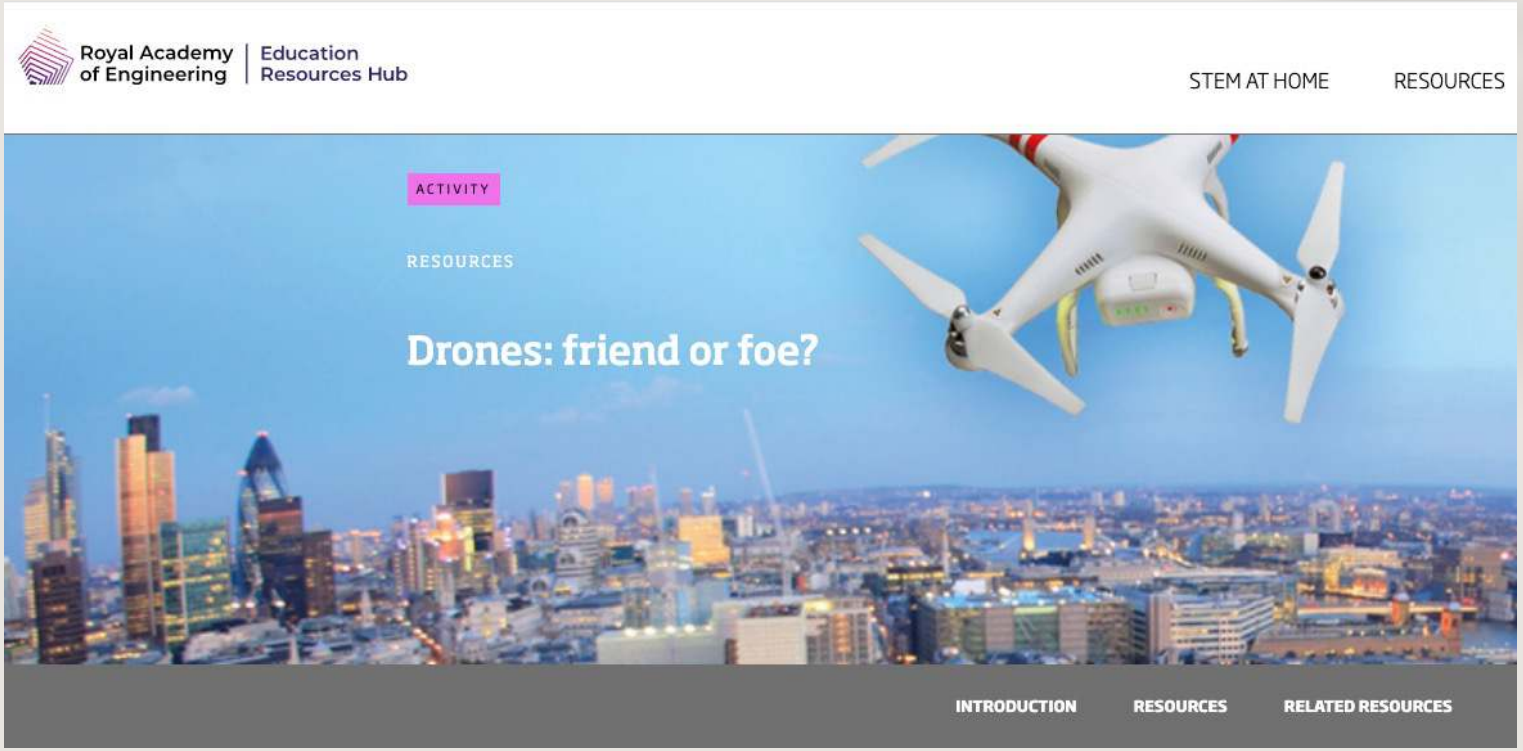
The human body	Sports	Satellites
Music	Electric motors	Electromagnetic waves (*block*)
Traffic	Work (*block*)	How does science develop
Motions (*block*)	Physics around 1900	Open research
The weather	Automation	Preparation for examination
Energy	Particles in fields (*block*)	
	Ionizing radiation	
	Optional investigations	

Note. Adapted from Dekker and Van der Valk (1986). Much of the classical physics topics taught in physics courses today could be integrated into a thematic unit on drones.

Example 1

Figure 3

Drone Resource Set Homepage

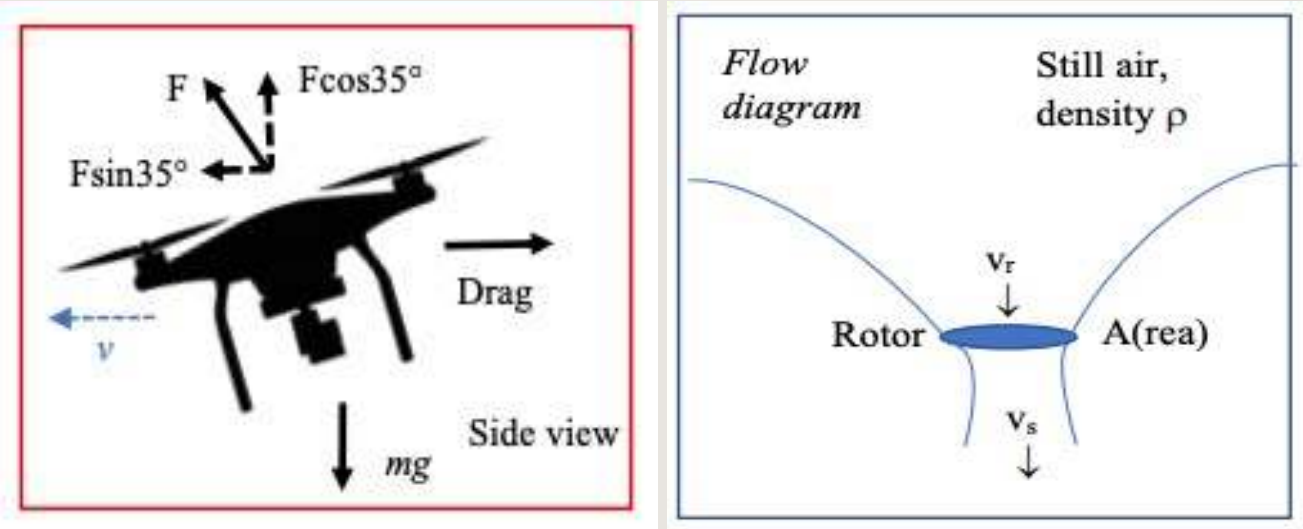


Note. Available at Royal Academy of Engineering's Education Resources Hub. Educators can download a series of six integrated STEM lessons designed for grades 6-10 on the theme of drones.

Example 2

Figure 4

Example Pre-University Physics Course Concepts Related to Drones

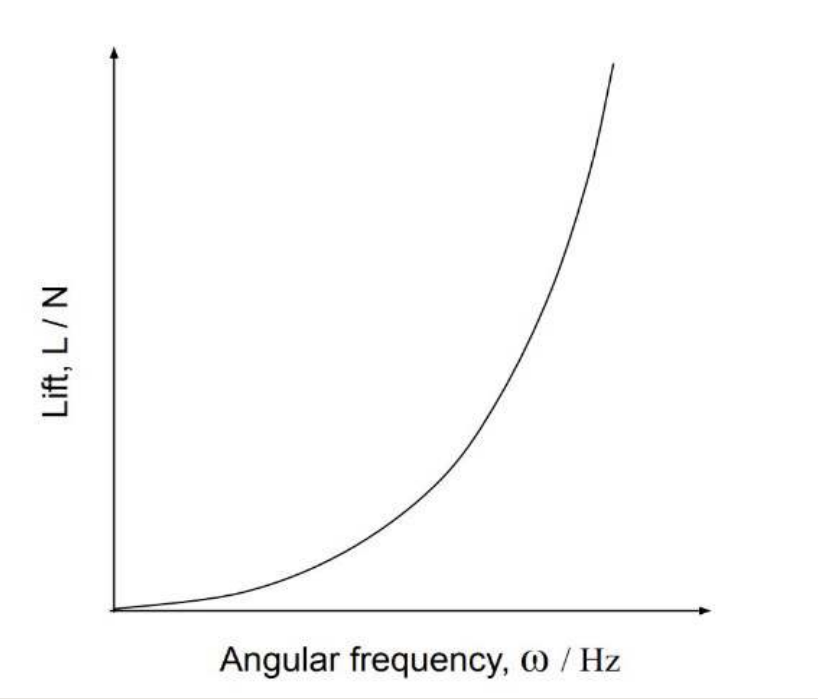


Note. Adapted from Reid (2020).

Example 3

Figure 5

Theoretical Model of Drone Lift Force vs Rotor Speed



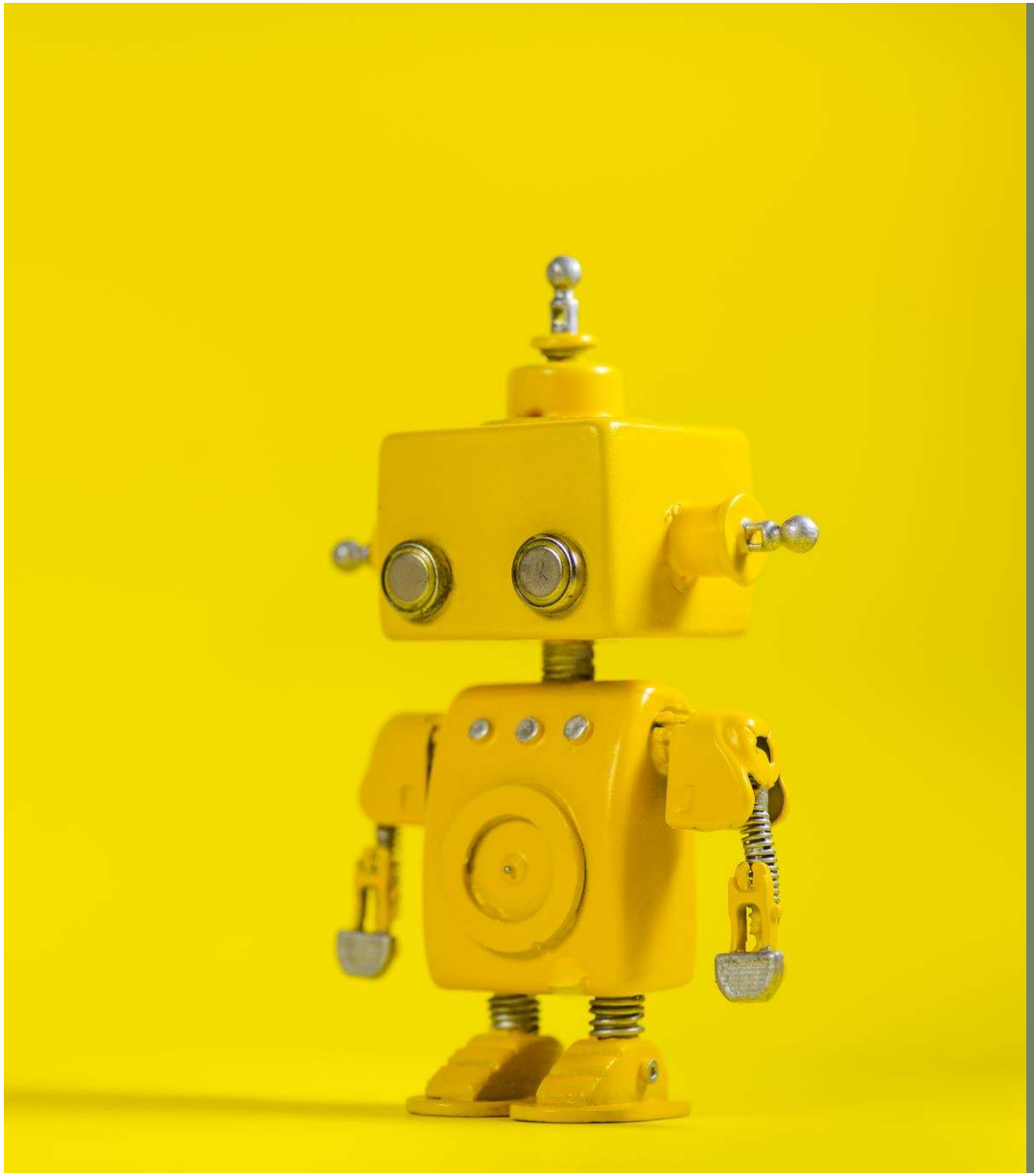
$$L = \frac{1}{2}\rho\omega^2 K_L{}^2 A_{disk}\left(\frac{1}{A_s{}^2} - \frac{1}{A_\infty{}^2}\right)$$

Note. Adapted from Lee (2020). The equation and graph are the original work of a Grade 12 physics student and were synthesized from their research into the topic of drones.

Figure 6
Robolink's Codrone Lite

Recommended Hardware

Note. Available from the Robolink online store. Due to the product's intended use being mainly for the teaching of design and coding, the cost could likely be shared between two departments.



Benefits of educational robotics to learners

Almost universally improves enagement and learning in STEM disciplines (Arís & Orcos, 2019)

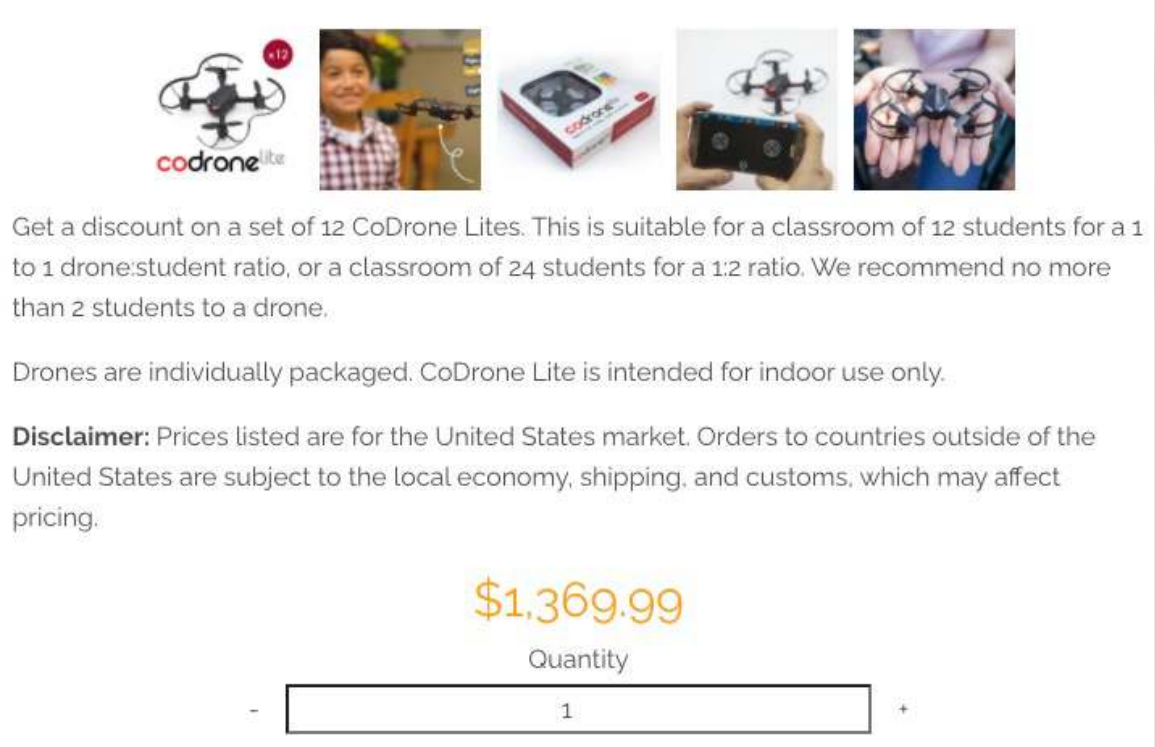
Develops 21st-century skills, even in students who are not planning to study STEM majors (Ma & Williams, 2013)

Disadvantages

Cost

Figure 7

Purchase Cost (in USD) of a Class Set of 12 Codrone Lites



Note. Available from the Robolink online store.

Figure 8

Example section of the IB Physics syllabus relevant to drones

Subtopic	Subtopic Number	IB Points to Understand
Motion	2.1	• Distance and displacement • Speed and velocity • Acceleration • Graphs describing motion • Equations of motion for uniform acceleration • Projectile motion • Fluid resistance and terminal speed
Forces	2.2	• Objects as point particles • Free-body diagrams • Translational equilibrium • Newton's laws of motion • Solid friction
Work, energy and power	2.3	• Kinetic energy • Gravitational potential energy • Elastic potential energy • Work done as energy transfer • Power as rate of energy transfer • Principle of conservation of energy • Efficiency

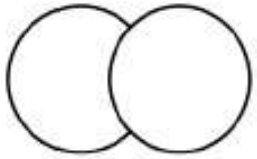
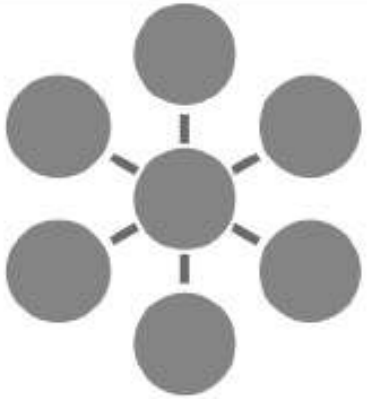
Curriculum re-mapping effort

Note. Adapted from Seigel (2021). An academically rigorous thematic drone unit would require careful mapping of topics to a detailed list such as the one shown above.

Linking to other STEM areas

Figure 9

Shared and Webbed Models of Integrated Curriculum

Share 	Team planning and/or teaching that involves two disciplines, focuses on shared concepts, skills, or attitudes	Shared instructional experiences; with two teachers on a team it is less difficult to collaborate
 Webbed	Thematic teaching, using a theme as a base for instruction in many disciplines	Motivating for students; helps students see connections between ideas

Note. Adapted from Fogarty's continuum of integrated education, as cited in Anderson (2013).
In future, a thematic drone unit could include team teaching across STEM disiplines.

Example Integrated Application

Figure 10

VRAD (Virtual Reality Aerial Drone) Martian Survival Competition Banner

Note. Adapted from Robotics Education and Competition Foundation (2021).

Conclusion

- The emergence of drone technology creates a new opportunity to teach high school physics content in a thematic, engaging and project-based manner
- There is scope to expand such thematic units to include electrical physics topics as well as other STEM disciplines, thus bringing interdisciplinary STEM learning to higher grade levels

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