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Engaging Children in Engineering Design through the World of Quadcopters

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FEATURE ARTICLE

engaging children in engineering design through the world of quadcopters

by Greg J. Strimel, Scott R. Bartholomew, and Eunhye Kim

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The interest in engineering education for K-12 students has been rising (Carr, Bennett IV, & Strobel, 2012; Strimel, Grubbs, & Wells, 2016), and the importance of engineering education is discussed as early as the elementary school level (Hegedus, 2014). Petroski (2003) claims that children are ready to learn engineering because their play activities are similar to engineering and design activities, such as making, moving, and rearranging things. Studies have examined how elementary school students perceive engineering or engineers (Cunningham, Lachapelle, & Lindgren-Streicher 2005) and found that elementary-aged students associated engineering with repairing, installing, driving, constructing, and improving machines and devices. Similarly, Capobianco, Diefes-Dux, Mena, and Weller (2011) found that elementary school students in Grades 1 through 5 perceive engineering as fixing, building, making, and using vehicles, engines, and tools.

In that context, engineering education is important to elementary-aged students because engineering design-based learning can help young students expand their limited perceptions of engineering beyond just using, fixing, and improving things (Cunningham & Hester, 2007) to include the practices of informed design (Dym, Agogino, Eris, Frey, & Leifer, 2005; Grubbs & Strimel, 2015). Engineering activities can also help students foster teamwork and collaboration skills as children work together in open-ended design environments (Hammack, Ivey, Utley, & High, 2015). Furthermore, engineering learning environments can support children in developing abilities to understand problems, plan and develop solutions, and share their ideas with others (McCullar, 2015). Studies also show that engineering activities for children can indirectly influence their learning and achievement in science and mathematics (Katehi, Pearson, & Feder, 2009). In the long term, exposure to engineering education can assist elementary school students in developing career aspirations for engineering and other STEM careers (Capobianco, French, & Diefes-Dux, 2012; Hegedus, 2014; Katehi, Pearson, & Feder, 2009).

Figure 1. Quadcopters use four propellers to generate lift.

There have been multiple attempts to integrate engineering education into the elementary school curriculum such as Engineering is Elementary from the Boston Museum of Science, Launch from Project Lead The Way, and the Technology, Engineering, Environment, Mathematics, and Science (TEEMS) curriculum by Engineering byDesign™. It is evident from these initiatives that engaging students in engineering at an early age is important to helping children understand engineering-related career opportunities, involving students in integrated STEM learning, and aiding in developing student skills for solving the challenges of the future. Whether or not a school chooses to implement one of the established elementary engineering curriculum programs, all elementary teachers can develop engaging engineering design-based activities that spark students' interest in engineering-related careers and develop their abilities to design, tinker, make, invent, and innovate. This article will explore one engaging way to expose students to engineering at an early age through the context of quadcopters. As stated by Sutton, Busby, & Kelly (2016), quadcopters "represent an intersection where science, technology, engineering, and mathematics come together in a practical way" (p. 8).

what are quadcopters?

A quadcopter is a small, unmanned aerial vehicle (UAV) equipped with four vertically oriented propellers or rotors that spin to generate the lift and thrust necessary to achieve flight (Figure 1). Quadcopters are different than traditional helicopters in that a quadcopter has pairs of rotors fixed at a specific pitch that are rotated at different speeds to achieve movement. Alternatively,

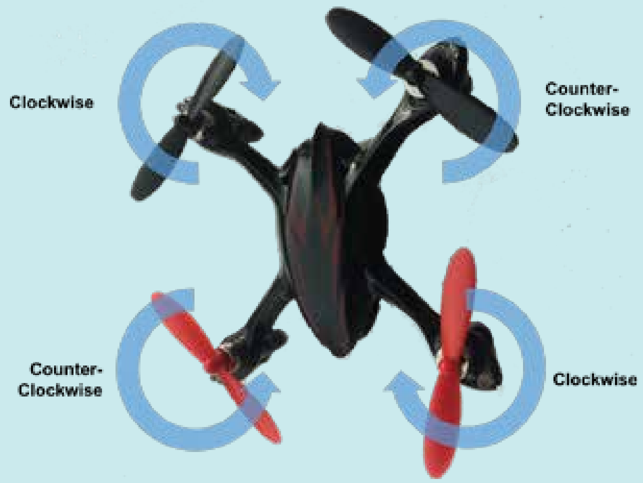

Figure 2. The spinning rotors of a quadcopter.

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helicopters use a dynamic rotor system that is adjusted to provide the thrust necessary to travel in a desired direction. Quadcopters are either piloted remotely by an operator or programmed to fly autonomously; conversely, helicopters are traditionally manned and navigated by onboard pilots.

The abrupt surge in popularity and prevalence of quadcopters can be attributed to technological advancements that have resulted in easier piloting and lower costs for production (AUVSI, 2013). However, this sudden spike in public admiration has also contributed to confusion over the name of these aerial vehicles—names such as: unmanned aerial systems (UAS), multirotors, multicopters, drones, and others are all used interchangeably. Currently, the most commonly used term to describe a remotely piloted copter operating with four rotors in an "X" or "+" shaped pattern appears to be "quadcopter" (UAV Couch, 2015).

how do quadcopters work?

One reason quadcopters have become popular is their simple structure (Gao, 2013), consisting of a frame with four motor-mounted propellers (rotors), a flight controller, four electronic speed controllers, a power module, a battery, and a radio controller (UAV Couch, 2015). More advanced quadcopters may include a Global Positioning System (GPS) for navigation and a telemetry radio (used for a connection between the aircraft and a ground station to transmit data). As seen in Figure 2, the four rotors spin (two rotors rotate in a clockwise direction, while two rotate in counterclockwise direction) to provide lift and directional thrust for the vehicle.

Quadcopters have six degrees of freedom (Figure 3), which translates to translational movement along the X, Y, and Z axes and rotational movement along each axis that results in roll, pitch, and yaw motions. The motion along the three axes is controlled by the speed at which the different rotors spin rather than by changing the direction of the rotors. When the speed of the rotors is changed in different combinations, the quadcopter will move in different translational and/or rotational directions. Figure 4 provides an illustration of different movements based on the speed at which each rotor spins. The speed of each rotor is adjusted independently by electronic speed controllers connected to each motor.

how are quadcopters used today?

Quadcopters are currently used for a variety of purposes in military, commercial, and personal applications. Military

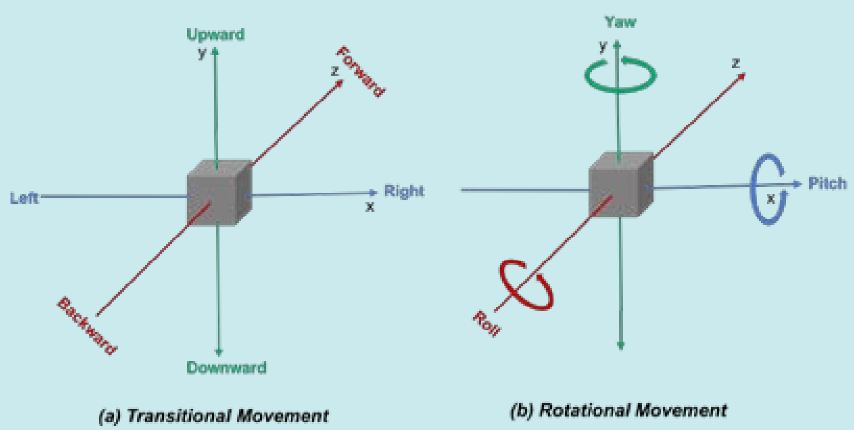

Figure 3. Six degrees of freedom: (a) A quadcopter can move longitudinally (forward and backward), vertically (upward and downward), and laterally (right and left). (b) It can also move rotationally among each axis to produce roll, pitch, and yaw movements.

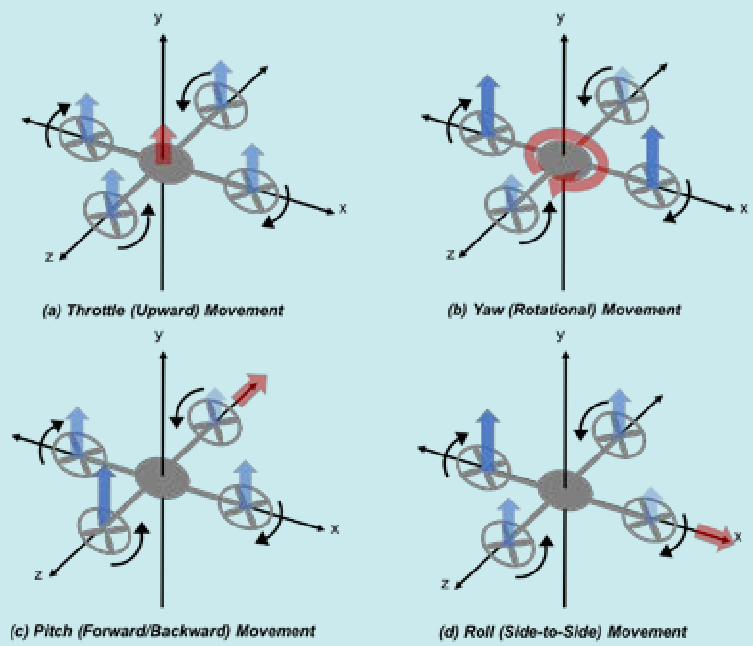

Figure 4. The movements are based on the speed of each rotor: (a) If all rotors spin at the same speed, the quadcopter will move upward. (b) If the speed of two rotors spinning in the same direction is higher than the speed of the others, the quadcopter will rotate on the Y-axis. (c) and (d). If two rotors spinning in the same direction rotate at the same speed while the other two rotors spin at a low and high speed, the quadcopter will tilt (change pitch or roll) and then move forward or backward along the Z axis; or side-to-side along the X axis.

organizations have employed quadcopters primarily to conduct intelligence, surveillance, search, and reconnaissance missions (Norris, 2014). Current uses can also involve the penetration of potentially hostile buildings prior to soldiers entering, providing real-time video of potential treats within the building. However, quadcopters are limited in carrying capacity by nature, and are thus considered inappropriate for direct combat deployments (Norris, 2014).

Law enforcement agencies use quadcopters equipped with camera systems, radio equipment, and sensors to conduct surveillance and criminal investigations. Disaster response and relief operations (Measure, 2015) and data collection and surveys (McNeil & Snow, 2016) are some other areas currently influenced by quadcopter integration. Commercially, quadcopters play a major role in advertising, real estate, and media because of their capability to quickly and easily access specific locations with high-quality camera systems for aerial photography and videography.

the future of quadcopters

Interest in the commercial applications of quadcopters will likely continue to rise as they are equipped with more advanced imaging systems and sensors and become capable of carrying heavier payloads (Skylogic Research, LLC, 2016). In 2013, Amazon.com launched Amazon Prime Air, the novel delivery system bringing packages to customers within 30 minutes via UAVs (Stern, 2013). In 2016, researchers at Virginia Polytechnic and State University (Virginia Tech) began to test the use of UAVs to deliver food orders from a restaurant to students. Despite these innovative efforts, safety, privacy and security issues loom large with regard to commercial quadcopter use (FAA, 2016).

quadcopters in K-12 classrooms

Quadcopters can be considered educational tools to stimulate students' interests and prepare them for potential STEM career opportunities (Preble, 2015). Preble (2015) posited that UAV activities allow students to learn the nature of technology, how technology is related to other fields, and how technology affects aspects of our society, culture, economy, politics, and environment. Sutton et al (2016) added that, with multicoptors, teachers can achieve integrative STEM learning by teaching science and mathematics along with technology and engineering design-based pedagogies.

In conclusion, the authors have developed a sample engineering design-based lesson for using quadcopters as a means to engage children in engineering, expose them to potential engineering-related careers at an early age, and integrate STEM learning through an engineering design challenge. The lesson overview and the full lesson plan created following the Engineering Design-Based Lesson format presented by Grubbs and Strimel (2015) are provided in Tables 1 and 2. The engineering design challenge is presented in Table 3. These tables can be found on the ITEEA website at https://www.iteea.org/111932.aspx.

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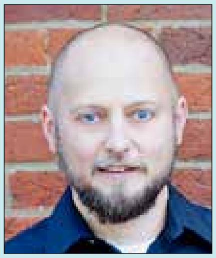

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