HUMMINGBIRD® ROBOTICS KIT

Research Findings

This document summarizes the most important findings from academic research studies involving the Hummingbird Robotics Kit.

1. The Hummingbird Robotics Kit is the result of a careful research process.

The Hummingbird Robotics Kit is the end result of five years of National Science Foundation- backed research at Carnegie Mellon University into developing creative robotics activities for use in- and after-school. This research progress is demonstrated in these papers [8, 9, 10, 11, 12].

The research process that led to Hummingbird included design feedback from and the direct participation of middle school girls from 2006 (42 girls) to 2008 (17 girls) [8, 10].

Ten teachers participated in Carnegie Mellon research to integrate the Hummingbird Kit with core curriculum in 2010 and 2011. Carnegie Mellon researchers then trained 127 additional teachers in 2012 to use Hummingbird, with teachers creating a wide variety of projects in all core subjects [7].

2. Students and teachers recommend the Hummingbird Robotics Kit.

In a study [4] of 274 students at one middle school participating in Hummingbird robotics projects that were integrated into core curriculum, 88.7% of student responses recommend that these projects be offered to other students, 5.4% are neutral, and 4.8% do not recommend them. In a further study [1] of 420 middle school students asked after their first Hummingbird-based creative robotics projects, 79.3% of students reported enjoying the project, 12.6% did not, and 7.1% had a mixed response. In both studies students completed Hummingbird projects as part of a required class, and did not self-select into the class due to prior interest in robotics or related fields.

From 2013 to 2015, Carnegie Mellon researchers trained 15 middle school teachers in two school districts to integrate Hummingbird-based creative robotics projects into their core disciplines [2, 5]. After approximately twelve hours/two days of summer PD, these teachers successfully implemented creative robotics with Hummingbird in the subsequent school year into health/PE (2 teachers), ELA (3 teachers), art (4 teachers), science (3 teachers), social studies (2 teachers), and integrated STEM (1 teacher). All 15 teachers rated the projects as enhancing their teaching practice. On a seven point scale, teachers also reported the project "enabled them to use technology more fully in class (mean 6.57), provided an opportunity to do group work (mean 6.47), offered a new way to engage my students in the topic we studied (mean 6.39), and extended or deepened my coverage of the topic we were studying (mean 6.11). Teachers also scored significantly higher on a measure of mathematics teaching self-efficacy in a pre-post comparison.

3. Participating in Hummingbird-based projects boosts 21st century skills.

"21st century skills" is a shorthand phrase for the idea that the skills required to succeed in modern workplaces include both technical problem solving and the ability to work in teams, persist in uncertain situations, and self-organize to solve problems. Schools can prepare students for these workplaces by providing opportunities to develop and practice 21st century skills.

Carnegie Mellon researchers conducted a study [6] of Hummingbird-based creative robotics projects at six middle schools/thirteen classes with over 230 students between 2010 and 2014. They found statistically significant improvements in both student technical skills and student motivation and confidence. These findings spanned Hummingbird projects integrated into english language arts, history, advanced math, and technology education. Gains were seen after students completed just one creative robotics project requiring eight 45-minute classroom periods.

In a further study [1] with 727 middle school students and 24 teachers in 66 classes in two school districts (one rural, one suburban), researchers replicated the student learning result of the previous study. They also found that students improved their understanding of what engineers do, with girls improving in this category more than boys.

4. Hummingbird projects help to close gender gaps in confidence and engineering career perception.

In a study [1] of 727 students (24 teachers, 66 classrooms, 2 school district, one rural, one suburban) in which responses were analyzed by gender, researchers found four statistically significant differences between girls and boys:

1. In student responses to open-ended questions, girls provided fewer negative responses to the question "What was the best thing you learned?" than boys (2.4% vs 7.6%).
2. In student responses to open ended questions, girls self-reported improved confidence in technology more often than boys (14.8% of girl responses vs 8.1% of boy responses).
3. In student responses to open-ended questions, girls were more likely to note that one reason they enjoyed the project was because it was multidisciplinary or creative (11.2% of girls vs 2.4% of boys).
4. In a measure of engineering career perceptions, both girls and boys improved on a standardized pre and post assessment. On the pre assessment, boys outperformed girls on this measure; on the post assessment, average scores for girls were no longer statistically different from those of boys. The researchers concluded that female students caught up to their male peers on this measure as a result of the creative robotics experience.

These changes were noted after 8 class periods (45 minutes/period) of Hummingbird-based creative robotics experiences. The projects were integrated into core curriculum, as such, student participants completed these projects as part of required courses.

5. Hummingbird-based projects can provide teachers insight into their students' talents.

In one study [3], Carnegie Mellon researchers trained teachers of core subjects with little familiarity of computer science or engineering to use Hummingbird projects to help them identify computational thinking (CT) and engineering design (ED) talent among their students. Teachers were asked to rate their students before and after a Hummingbird project on their impression of student skill in CT and ED. For 10% of students, teacher evaluations of their talent relative to the rest of the students changed by over 50 percentile from before the project to after it. As one science teacher noted "..when this new lesson comes into play…, sometimes you see different sides to people. You see a different ability that was hidden."

6. Hummingbird-based robotics projects can be integrated into any subject.

Carnegie Mellon researchers tracked the implementation of Hummingbird-based robotics projects at one school over three years [4]. Two case studies of Hummingbird-based creative robotics projects, one in english language arts, and one in health and physical education, demonstrate the evolution of student performance and teacher confidence over these three years, eventually leading to deeper content integration by teachers and increased technical proficiency in project design by students.

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Carnegie Mellon researchers conducted a study [6] of Hummingbird-based creative robotics projects at six middle schools/thirteen classes with over 230 students between 2010 and 2014. They found statistically significant improvements in both student technical skills and student motivation and confidence. These findings spanned Hummingbird projects integrated into english language arts, history, advanced math, and technology education. Gains were seen after students completed just one creative robotics project requiring 10 or fewer classroom periods.

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