

Executive Summary

***Speedometry* Evaluation Final Technical Report**

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Scope

Efforts to improve student participation in science, technology, engineering, and mathematics (STEM) have captured national and local attention. One major effort in this vein is the development and widespread adoption of Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS), which seek to promote students' deep understanding both of STEM content and scientific practices (NGSS, 2015). Three challenges relevant to this report stand out: (1) students of color and female students are underrepresented in STEM classes, higher education, and careers (e.g., Sadler et al., 2012), (2) sustained interest and engagement in STEM, particularly among underrepresented groups, is necessary to increase participation in STEM fields, and (3) relatively few well-designed curricular resources exist to help teachers implement the new standards in engaging ways. Researchers at the USC Rossier School of Education, with funding from the Mattel Children's Foundation¹, developed *Speedometry* to begin to address the dearth in resources with an engaging curriculum that would foster student interest and learning. This report details findings of a large-scale field test of *Speedometry*. The field test sought to determine the curriculum's effectiveness for both students and teachers. Specifically, we collected data on how curriculum implementation affected student interest and engagement in STEM, student content knowledge, teacher beliefs about STEM teaching, and teachers' pedagogical practices.

Background

Speedometry is the outcome of a partnership between USC's Rossier School of Education and the Mattel Children's Foundation (MCF). The partnership stems from a shared belief that a freely available curriculum built around familiar toys and incorporating innovative pedagogy aligned with rigorous educational standards could catalyze student engagement in



¹ The Mattel Children's Foundation was not involved in the design, conduct, or analysis of the research and had no influence over the reporting of results.

STEM and potentially be replicable in a variety of contexts. In dialogue with funding partners at MCF, our research team at USC designed a three-phase project whereby we would (1) develop a new curriculum using Hot Wheels to teach STEM content, (2) pilot test and revise it, and (3) conduct a large-scale field test of the curriculum.

We began by assembling a team of experts in science learning, methodology, mathematics and science curriculum content, and teacher education. The team selected 4th grade as the target grade level because of the large number of mathematics and science standards that could be addressed with the toy cars and track. Next we recruited expert 4th-grade teachers to ensure that we developed a curriculum that would effectively convey standards content and provide the support teachers need for implementation (through both the materials themselves and high quality professional development videos). Once developed, the curriculum was pilot tested in 16 classrooms in 2013. Based on these results and on feedback from participating teachers, we revised the curriculum with help from our teacher consultants, and created the current version of *Speedometry*. Finally, we conducted a field test across an entire school district to assess *Speedometry's* effectiveness in increasing student engagement, interest, and content knowledge in STEM subjects. We also investigated the curriculum's utility for teachers: how easy or difficult it was to use as intended, and to what extent it may have helped them feel more confident about teaching science and mathematics according to the new education standards. The results of the field test are detailed in this report.

Methodology Highlights

In order to assess the curriculum's effectiveness we conducted a cluster-randomized control trial (RCT), in which 59 4th-grade classrooms throughout one Southern California school district were randomly assigned to treatment or control conditions. We asked the following research questions:

1. **Implementation:** To what extent do teachers implement the *Speedometry* curriculum with fidelity?

2. **Student knowledge:** What is the impact of the *Speedometry* curriculum on students' content knowledge, and to what extent does the impact vary according to student gender and English language learner (ELL) status?²
3. **Student interest/emotions:** What is the impact of the *Speedometry* curriculum on student interest and emotions, and to what extent does the impact vary according to student gender and ELL status?
4. **Effects on Teachers:** What effects does *Speedometry* have on teacher outcomes, including their confidence to teach mathematics and science, and their instructional practice?

Prior to beginning the RCT we conducted a brief professional development session (PD) for all 4th-grade teachers in the school district. Since we wanted their PD to be similar to the assistance available to any teacher across the country who might download and teach the curriculum, our PD was centered around the 14 online videos we had developed. In addition to screening the videos, we spent approximately an hour answering questions, outlining the study logistics, and distributing the curriculum and materials.

We used a mixed-methods approach in study design and analysis, relying on a combination of teacher and student surveys, student tests, classroom observations, student focus groups, and teacher interviews. Prior to implementing the curriculum, all teachers were surveyed about their teaching professional history, their beliefs about teaching science and mathematics, and their instructional approach. They were then randomly assigned to a Treatment group or to a Delayed Treatment (control) group that implemented the two-week curriculum two weeks after the treatment group. The control group filled out an additional, brief survey about what they taught while the treatment group was teaching *Speedometry*, and then all teachers completed a post-survey, which revisited the questions of the pre-survey and also asked about implementation process and its effects. Students took online pre- and post- tests to assess their content knowledge and an online post-survey to assess their interest. All treatment classrooms were visited once to assess the fidelity of implementation. Finally, we deepened our understanding of teachers' and

² We were unable to test for racial/ethnic differences in impacts due to data availability.

students’ experiences with semi-structured interviews, classroom observations, and student focus groups in a sub-set of case study teachers’ classrooms.

Table i

Study Instruments

Instrument/Source	Description
Teacher surveys	Pre-survey (all): measures teaching experience, beliefs, and confidence; familiarity with relevant content and standards Control group survey: measures what was taught while the treatment group was implementing <i>Speedometry</i> . Post-survey (all): measures teaching experience, beliefs, and confidence; familiarity with relevant content and standards; fidelity of implementation; views on how <i>Speedometry</i> affected them and their students
Fidelity checks	One visit to each treatment group classroom to assess fidelity of implementation
Student assessments	Online pre- and post-assessments of knowledge of curriculum content
Student surveys	Online surveys assessing interest in and emotions about <i>Speedometry</i>
Case study teacher interviews	4 semi-structured interviews about teacher experiences implementing <i>Speedometry</i> (7 teachers)
Case study classroom observations	3 visits to each case study teacher’s class to observe teaching of <i>Speedometry</i>
Student Focus Groups	Focus group interviews, each with 4-6 students, in 5 case study classrooms
Administrative data	Information about student gender, English language learner status, and special education eligibility; provided by the school district

Findings

Our study yielded findings in four primary areas, based on our research questions.

1. *Speedometry* was implemented with high fidelity. In classroom observations we found that 94% of curriculum elements were implemented as intended, and 73% of individual teachers

implemented the curriculum with complete (100%) fidelity. According to teacher survey responses, 88% percent of teachers reported completely implementing the curriculum elements listed on the survey.

The high fidelity of implementation we observed may be partially explained by the professional development (PD) teachers received. Indeed, in post-surveys, 89% of teachers reported that the PD helped them implement the curriculum. The PD could also partially explain why a mere 5% of teachers reported that *Speedometry* was “somewhat difficult” to use, while 95% reported that it was either “easy” or “neither easy nor difficult” to use (Figure i).³

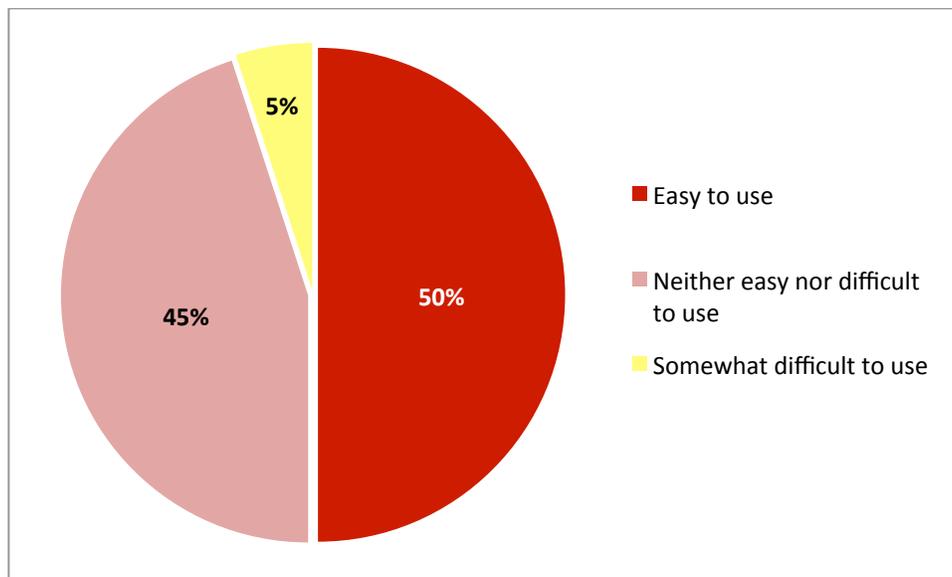


Figure i. Teacher feedback on ease of implementing *Speedometry*. (Response to the question “Overall, how easy was it to use the *Speedometry* unit?”)

2. Students’ knowledge of mathematics and science content increased. Adjusting for student-level characteristics, the *Speedometry* curriculum led to a 0.41 standard deviation increase in content knowledge assessment scores. In terms of number of items correct, treatment group students, on average, out-performed control group students by 1.34 points on a 20-point test (see

³ Teachers in our study received a set of worksheets for the entire class, which also may have contributed to ease of use. In practice teachers will have to print their own worksheets (though templates are provided).

Figure ii, below). Our data also indicate that the impact of Speedometry does not vary by gender, English language learner status, or special education eligibility.

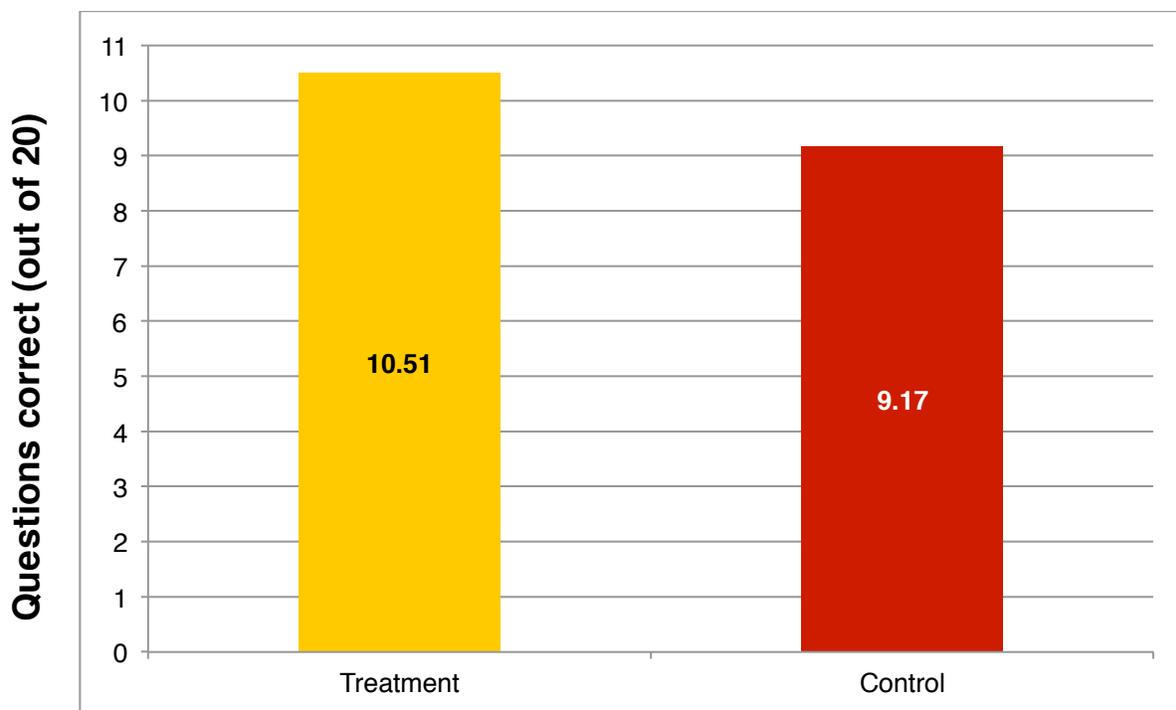


Figure ii. Student knowledge effect (posttest score) by treatment group.

Survey responses from teachers were consistent with our statistical analyses of student knowledge. Fully 95% of teachers reported that student learning of science content moderately or greatly improved as a result of *Speedometry*, while 79% reported student learning of mathematics content moderately or greatly improved. Several teachers reported hearing students discuss important *Speedometry* content such as kinetic and potential energy at recess, connecting it with the motion of a ball during a game of catch, or to students going down the slide. Similarly, participants in all five student focus groups were able to tell us that *Speedometry* taught them about kinetic and potential energy. One girl explained, “Kinetic [energy] is when—energy that makes things move. Potential [energy] is start-up energy for the future.”

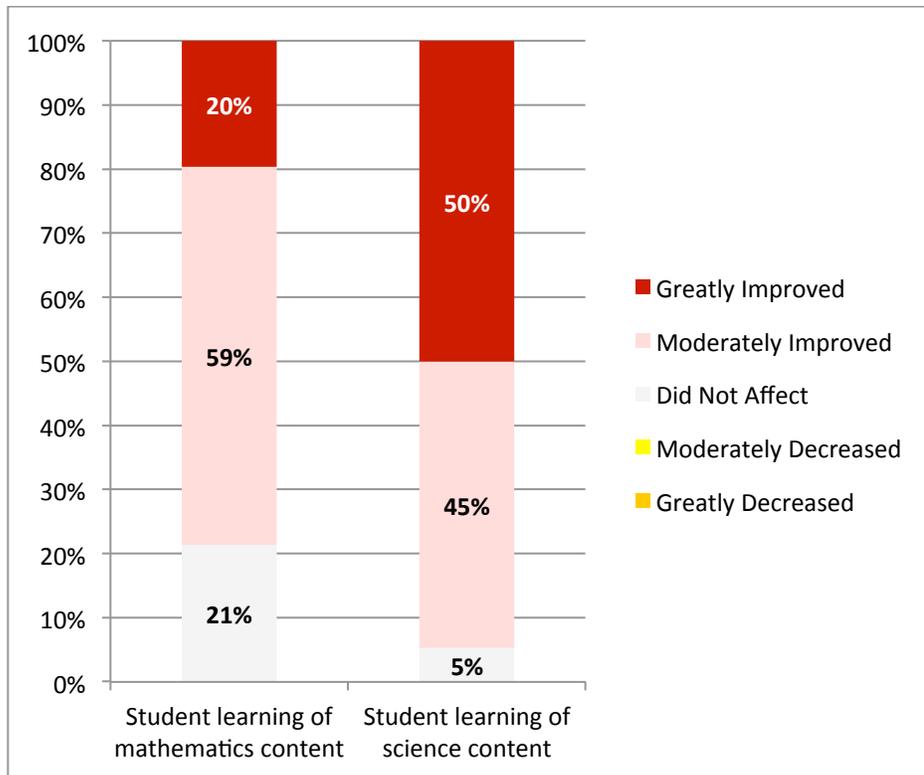


Figure iii. Teachers' reported beliefs about Speedometry's effects on student learning.

3. Speedometry students showed greater interest, more positive, and less negative emotions relative to the control group.

The curriculum successfully met our objective to foster STEM interest and engagement for students. According to student interest surveys, students across demographic groups found *Speedometry* more engaging than the science



instruction received in the control classrooms. These positive impacts were found for girls and boys, English language learners, and students eligible for special education. Interestingly, girls' *negative* emotions about science and mathematics were found to be *lower* as a result of *Speedometry* relative to the control classrooms. This finding is particularly notable because decreasing negative emotions may have an even greater effect on girls' sustained interest in STEM than would increasing positive emotions (Sinatra, Broughton, & Lombardi, 2014).

Teachers also reported high student engagement on their post-surveys. Fully 100% of teachers reported that student motivation and student engagement moderately or greatly

improved as a result of *Speedometry*. They consistently used words like “excited” and “engaged,” to describe the students during *Speedometry* lessons. One case study teacher told us that the curriculum was “powerful.” Another said, “They [the students] found joy.” In focus groups students told us they liked the *Speedometry* lessons and enjoyed learning through them. One student told us, “I liked the fact that we really had to use our heads. It challenged my brain.”

4. Teaching *Speedometry* was associated with reported increases in teachers’ confidence to teach science and mathematics. Many elementary school teachers are intimidated teaching mathematics and science (Nadelson, Callahan, Pyke, Hay, Dance & Pfiester, 2013), and even confident mathematics and science teachers may wonder about their ability to teach skills connected to new standards such as the CCSS or NGSS. For these reasons, we hoped that teaching *Speedometry* would enhance teacher confidence, and increased confidence was indeed associated with teaching *Speedometry*. Teachers’ pre- and post-survey responses indicated that their confidence to teach specific science-related skills especially increased, particularly “using evidence to construct an explanation relating speed of an object to energy of that object.” Survey responses indicated an increase of 0.75 points on a 4-point scale.

Survey data also indicate that implementation was positively associated with reported gains in teachers’ understanding of the inquiry-based instructional model undergirding the *Speedometry* curriculum. While we found that implementing *Speedometry* did not change teachers’ reported beliefs about the nature of instruction, more than 90% of teachers reported that they would be more likely to teach science inquiry skills in the future. These reported gains for teachers—in their understanding of and desire to teach science inquiry skills and confidence that they can successfully do so—may translate to future changes in practice and more positive learning outcomes for students.

Implications & Recommendations

The results of our RCT demonstrate great promise for the development of similar curriculum programs and their use in improving STEM instruction in schools. Our findings indicate that a standards-aligned curriculum coupled with high-quality materials and readily available professional development can promote student learning and positive emotions.

Furthermore, we have suggestive evidence from teacher surveys, interviews, and observations, that our intervention can promote meaningful learning among teachers in terms of their ability to understand and implement standards-aligned curricula. We hope that our work can serve as a model for future development and research around new curriculum materials, both to extend *Speedometry* to other grades and settings (e.g., after school), and also to encourage the creation of other programs to help teachers bring inquiry-based STEM learning to all students.

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