Indexing Crazy 8s:
Measuring the Effects of an Extra-Curricular Math Experience on Children's Math Attitudes

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Background

Math ability, from calculating personal debt to computing a simple restaurant tip, is critical to daily life in modern cultures. Previous research finds that mathematical competence is linked to career success, income, and psychological well-being [1-4]. Yet despite the increasing need for proficiency in science and mathematics, many US children and adults experience negative feelings and anxiety at the thought of doing math. These feelings of math anxiety correlate with math performance: in both adults and children, greater math anxiety is linked with poorer math achievement and reduced likelihood of engaging in activities that involve math [5-7]. Further, recent research reveals the presence of math anxiety in children as young as 5- to 6-years old [6].

One possible strategy for buffering against math anxiety early in development is to provide children with mathematical experiences outside of the classroom, in a context designed to be enjoyable, team-based, and not directly tied to classroom instruction or evaluation. This is the goal of Crazy 8s, an extracurricular math club for elementary school children in Kindergarten through 2nd Grade, and 3rd through 5th Grade, created and distributed by Bedtime Math. Children can enroll in a Crazy 8s club held at their school, public library, or after school recreation center. In small groups led by a Crazy 8s coach, children participate in 8 weeks of math-related activities designed to stimulate interest in and confidence about math.

The goal of this study is to quantify the effects of Crazy 8s participation. Characterizing how such experiences outside the classroom impact young learners is a critical step towards increasing math fluency and enjoyment, and may play an important role for designing effective remediation for children struggling with mathematics, without changes to school curricula. The project sought to answer three main questions:

1) **Does participation in Crazy 8s affect children's feelings about math?** Given that math anxiety develops early and is linked to poorer math performance and reduced engagement in math-related activities, there is a pressing need for strategies to reduce early math anxiety. It was hypothesized that 8 weeks of participation in Crazy 8s would decrease children's self-reported math anxiety.
2) **Does participation in Crazy 8s equally impact math anxiety in girls versus boys, and in younger versus older children?** Previous work finds that girls report higher math anxiety than boys, but it is unknown whether there also are gender differences in the malleability of math anxiety, and whether remediation is more effective at the start of formal schooling, versus after more educational experience has accrued.
3) **Does participation in Crazy 8s impact children's math anxiety, over and above the benefits conferred by participating in a non-math themed extra-curricular experience?** Any observed decreases in math anxiety could be caused by the general experience of being in an after-school club with other children. Therefore, it is important to ask whether the impact of Crazy 8s differs from the impact of participation in a non-math club of similar size and style.

Methods and Results: Initial Survey

In Fall 2015 and Spring 2016, data were obtained from 755 children who had volunteered to participate in Crazy 8s across the country. 362 children participated in the version of Crazy 8s designed for younger children in Kindergarten-2nd Grade (K-2), and 393 participated in the version designed for older children in Grades 3-5 (G 3-5). At the first club meeting (Week 1), prior to participating in the planned club activity for that day, children completed a survey in which they rated their feelings about engaging in math-related activities (e.g., "How would you feel if someone asked you to do a math problem with other kids watching?") and non-math-related activities (e.g., "How would you feel if someone asked you how to spell DOG?"), using a 5-point scale with cartoon faces that ranged from happy to neutral to sad. Subtracting children's ratings for non-math-related items from their ratings for math-related items provided an index of children's feelings about math specifically, controlling for general trait anxiety. This measure of 'relative math anxiety' has been shown to capture individual differences, and to correlate with performance on a standardized math assessment (WIAT-III; 6). Children also completed the same survey 8 weeks later, at the end of the club. At both time points (Week 1: Pre-club and Week 8: Post-club), surveys were administered to children as a group by club coaches, and then were mailed back to the research team for coding and analysis.

Of the 75 Crazy 8s clubs studied, 36% were held in public schools, 36% in libraries, 14.7% in center-based after school programs, 12% in private schools, and 1% in charter schools. Clubs were held in communities with a wide range of income levels. Median income in the neighborhoods housing the clubs ranged from just over $20,000/year to over $150,000/year.

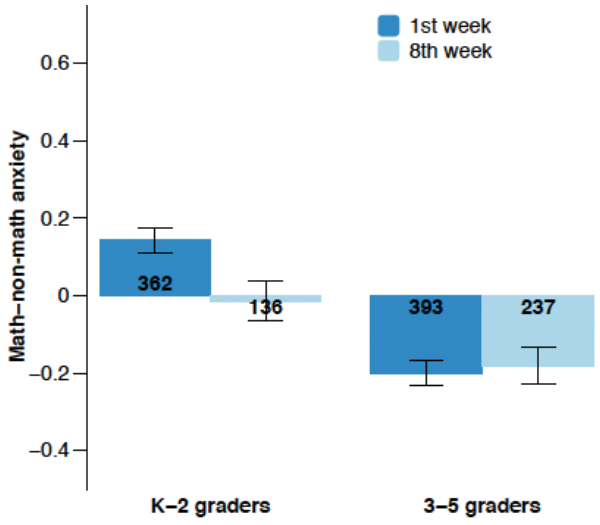

Figure 1. Change in children's relative math anxiety from Week 1 to Week 8 of Crazy 8s participation in Fall 2015-Spring 2016.

As shown in Figure 1, children exhibited a reduction in relative math anxiety (math anxiety minus non-math anxiety) over the course of enrollment in Crazy 8s. This change was significant in the younger children (K-2); no significant change in relative math anxiety was seen in the older children (G 3-5). Children in Grades 3-5 started the club reporting low levels of relative math anxiety, and did not experience significant change in these initial levels. One potential reason for this is self-selection--because children 'opted in' to Crazy 8s, and because older children's greater autonomy may lead them to select activities that closely match their existing interests, the sample of 3rd-5th graders may have disproportionately sampled from children who were already positively disposed towards math (see RCT section below). Additionally, and replicating previous work [6,8], girls reported higher math anxiety than boys; however, girls and boys exhibited similar amounts of change in relative math anxiety over the 8 weeks of club participation. The greatest

reduction in relative math anxiety was observed in children who began the study with the highest relative math anxiety scores.

Methods and Results: Randomized Control Trial (RCT)

The results of this first investigation provide suggestive evidence of the remediative benefits of Crazy 8s on children's math anxiety. However, the findings also raise several questions. The first question concerns the specificity of the observed effects: did participation in Crazy 8s, in particular, reduce children's math anxiety, or would participation in 8 weeks of any extra-curricular experience have had similar effects? Given that participation in a range of extra-curricular activities has been shown to positively affect student outcomes [9], it is important to know whether the math content of Crazy 8s was required for its success. Second, children in the initial study all volunteered (or were volunteered by parents) to participate in Crazy 8s. It is possible that this created a self-selection bias, whereby the children studied already were positively disposed towards math. Would children who did not self-volunteer to be in a math club experience similar benefits? Finally, it is noteworthy that the older children in our initial study both exhibited lower overall rates of relative math anxiety than the younger children, and exhibited less reduction in relative math anxiety. Self-selection is one possible explanation of these observations. The sample of older children in our initial study therefore may have disproportionately contained children with low initial levels of math anxiety, and hence less opportunity to show further reduction.

We addressed all of these issues with a Randomized Control Trial (RCT) in which a new sample of children was randomly divided into two groups. One group was assigned to participate in 8 weeks of Crazy 8s; the other was assigned to participate in Art in Action, a commercially available extra-curricular program aimed at stimulating interest and expertise in the visual arts. Art in Action was chosen as a control group because, relative to Crazy 8s, it was designed to have similar numbers of children in each club, similar pacing, and to involve a similar amount of dynamic social interaction.

In Fall 2016 we obtained data from 652 children in Maryland and New Jersey who were randomly assigned to Crazy 8s (36 clubs) or Art in Action (29 clubs) (Table 1). Each location (e.g., school or recreation center) offered at least one club of each type; this provided a yoked control for demographic differences among locations.

		Crazy 8s	Art in Action	Total
K-2	Week 1 (pre-club)	86	82	168
	Week 8 (post-club)	61	80	141
	Tested at both weeks	45	62	107
G 3-5	Week 1 (pre-club)	177	117	294
	Week 8 (post-club)	153	94	248
	Tested at both weeks	115	66	181

Table 1. Numbers of participants in Kindergarten – Grade 2 (K-2) and Grades 3-5 (G 3-5) in Weeks 1 and 8 of the Randomized Control Trial (RCT).

Children completed the math anxiety survey at Weeks 1 and 8. Unlike our initial assessment (described above), non-math anxiety items in the RCT focused on children's feelings about art (e.g., "How would you feel if someone asked you to make a sculpture out of clay and show it to your class?"); this allowed us to ask whether Crazy 8s impacted children's feelings about math (but not art), and whether Art in Action impacted children's feelings about art (but not math).

The RCT results revealed that children in both the younger (K-2) and older (G 3-5) age groups experienced a significant reduction in relative math anxiety (here defined as math anxiety minus art anxiety) over the 8 weeks of the club. **In contrast, children in the Art in Action control group did not show a significant reduction in relative math anxiety** (nor in relative art anxiety) (Figure 2). Among children in Crazy 8s, change in relative math anxiety did not differ for girls versus boys.

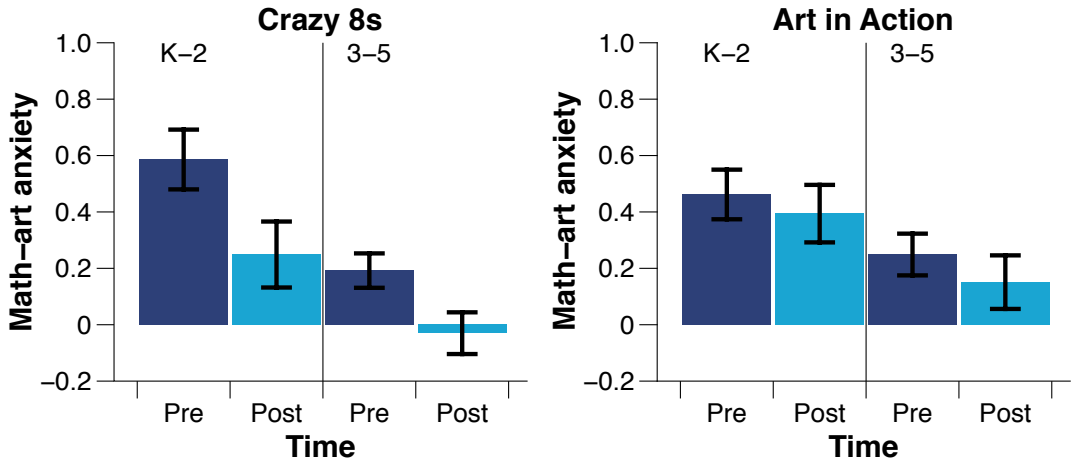

Figure 2. Relative math anxiety (math anxiety minus art anxiety) at Weeks 1 (Pre-club) and 8 (Post-club), for children participating in Crazy 8s (left panel) and Art in Action (right panel).

Furthermore, the RCT data suggest that the benefit of participating in Crazy 8s was resilient to variation among individual clubs. Although previous work finds that children's math learning is affected by their teachers' level of math anxiety [10], here no correlation was found between the math anxiety of club coaches (also measured by self-report survey) and the reduction in math anxiety experienced by the children they coached. This may be due to the structured nature of the club materials, and/or the fact that Crazy 8s does not involve the paper-and-pencil computations or evaluation of performance that may trigger more anxiety among both coaches and children. The data also revealed no correlation between children's attendance and math anxiety reduction; children who were not able to attend every club session exhibited the same degree of math anxiety reduction as children who attended all 8 weeks.

Discussion

In two independent samples, the extra-curricular math club Crazy 8s was observed to reduce relative math anxiety in children after 8 weeks of participation. This was first observed in a large sample of children who volunteered to enroll in Crazy 8s, and was subsequently confirmed in a Randomized Control Trial in which children were assigned either to Crazy 8s or to a matched control club with no math content. Math anxiety decreased among both older and younger children in the RCT; this effect was more pronounced among children in Kindergarten through 2nd Grade. Math anxiety was reduced to a similar extent among girls and boys. The finding that Crazy 8s reduced math anxiety to a significantly greater extent than the control art club suggests that its effects were specific: the math-related content of Crazy 8s changed children's feelings about math, over and above changes caused by general involvement in after school activities. Hence participation in Crazy 8s has positive impact on the attitudes of elementary school children towards math. Given the well-documented findings linking math anxiety to both math engagement and math performance, this type of extra-curricular experience may have lasting positive impact on children's outcomes.

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