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This paper was written before Creosity Space had changed its name from SmartKids NY. All references and data in the following paper to SmartKids NY (or SmartKids) are directly applicable to CreositySpace.

Connecting Kids to STEM Through Entrepreneurship and Innovation

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***Abstract* – In this paper, the authors outline preliminary results on the introduction of entrepreneurs and innovators in classrooms, demonstrating the positive impact on both teaching kids STEM, as well as influencing certain demographics to aspire to STEM-related careers. The authors hypothesize that connecting students to STEM in elementary school, primarily through the introduction to STEM-based entrepreneurs and innovators, will ultimately result in a more STEM-inspired and STEM-literate workforce. If this model is followed collectively by educators, business, and government alike, the authors believe that significant progress can be made in mitigating the loss of students interested in STEM during middle school.**

Index Terms – STEM education, Elementary school, Entrepreneurship, Innovation, Role models, Technology

BACKGROUND

SmartKids NY (SmartKids) is based on the belief that introducing kids to science, technology, engineering, and mathematics (STEM) in elementary school is integral to resolving the growing labor deficit for technically-skilled workers and STEM-knowledgeable employees [1]. Studies suggest that STEM workforce development should begin long before high school [2-4]. By 8th grade, nearly half of all middle school students "have lost interest or deemed it [science] irrelevant to their education or future plans." [5]

We believe the SmartKids model can serve as a bridge program to mitigate the perennial loss of interest in STEM among students entering middle school. This will ultimately lead to the development of a broader STEM-knowledgeable workforce ranging from bench scientists, engineers and educators to corporate executives, policymakers and service providers capable of building, supporting, and promoting an innovation economy [6].

We contend that a STEM workforce requires more than just actual STEM-degreed college graduates. Equally important is the need to attract, nurture and retain students who self-identify as someone who can *do* STEM, but whose skills and predispositions—coupled with their *interest in* and *comfort* with STEM—lead them to pursue non-STEM careers working alongside or promoting the efforts of engineers, scientists and entrepreneurs [7]-[8].

Achieving a broader STEM-literate workforce requires that we start with a larger percentage of middle school students interested in STEM. To achieve this, we need to rethink our workforce development strategy—from when we introduce students to career concepts to redefining expectations on the rate of return we hope to realize.

HOW SMARTKIDS DOES STEM

While the SmartKids program shares many common elements with other successful STEM initiatives (fun hands-on activities, involvement of STEM professionals), [9] SmartKids is unique with its applied entrepreneurship and innovation focus. SmartKids aims to spark early interest in STEM and boost the number of STEM-inspired students entering middle school by accelerating the introduction of entrepreneurs and innovators into the classroom. This begins in elementary school–a time when research shows kids begin to explore careers and consider what they might like to do when they grow up [10], and is accomplished by:

- Introducing relevant, real life role models who demonstrate both the breadth and application of STEM;
- Providing an in-school platform to kids that keeps STEM current, real and fun for the students; and
- Connecting kids to the innovations occurring in their community and beyond.

Entrepreneurs and innovators are uniquely positioned to inspire young students in STEM. They represent the diversity of STEM professions that extend beyond traditional civil engineering, coding and robotics—from biology, biotech and nanotechnology to cleantech, energy storage and materials science. This group is on the front lines of innovation launching technology startups, conducting forward-looking research, and creating new products to solve complex industrial and social challenges.

SMARTKIDS IN THE CLASSROOM

The SmartKids program is delivered in school as an extension of the current curriculum and provides tools to weave STEM into Math, ELA and social studies classes. Offering this program as part of the school day allows all students to participate—regardless of their socio-economic status, home situation, or academic capability. Doing this gives the greatest number of students the same opportunity to experience STEM from their own perspective in a non-testing, creative and interactive environment.

Schools were selected initially based on geographical proximity to the founder and their willingness to participate in a pilot program. Presenters were drawn from the

founder's personal cleantech network, and shared several characteristics thought to be key to help students self-identify with the presenter. Entrepreneurs and innovators were young and early on in their career, represented diverse academic and ethnic backgrounds, and between 30-50 percent were female.

In addition to offering small group, hands-on demonstrations and activities, a typical SmartKids session runs 75-90 minutes with ample opportunities for students to interact with the presenter. Our current content—educator guides, activities, and the *Book of Ideas*—was piloted in September 2014, and provided in a format to help new and existing teachers feel more comfortable with STEM concepts. Equally important, it enables elementary teachers to:

- Develop understandings of real applications of STEM;
- Use hands-on activities in the classroom;
- Infuse science into other subject areas, including ELA, math and social studies, to meet teaching requirements as set by Common Core or Next Generation standards.

Growth has continued over the past year. In an effort to expand program accessibility, both geographically and among school types, SmartKids is developing an online platform to house digital content. The online platform will give educators and parents the flexibility to tailor the SmartKids program to meet their needs.

PROGRAM ASSESSMENT

Observations of 72 presentations between November 2013 and June 2015 revealed many qualitative outcomes ahead of any quantitative assessment. Among them:

- Students collaborated with each other to problem solve;
- Students taught each other;
- Students informed presenters about their own products;
- Academically-challenged, quiet or otherwise disengaged students participated fully;
- Students openly shared their own ideas around the technologies presented.

Entering the 2014-2015 school year, SmartKids aimed to develop a more quantitative assessment of the program and began administering a set of pre-presentation and post-presentation surveys. Examples of these surveys are available in Appendix 1. These surveys were designed to give initial insight into the following two program goals:

- Do the students feel like they are learning some new vocabulary and concepts?
- Do STEM-based entrepreneurs and innovators, who can act as role models in the class, increase the percentage of students interested in STEM-based careers?

This initial evaluation included 700+ surveys associated with a variety of presentations. The companies and concepts covered in this initial assessment ranged from electronics, coding and biology, to energy storage and materials development.

The surveys included three vocabulary/concept-based questions in which students were asked to rank "how much they knew" about a certain vocabulary word or concept. Sample questions include, "What do you know about physical computing?" or "What do you know about microbial fuel cells?" The ranking was subjective, from the student's perspective, on a scale of 0-5, where 0 represented "I don't know anything" and 5 represented "I know a lot." Students were **not** asked to support their ranking with any additional evidence on their level of understanding, therefore these questions probed more what they thought of their ability to understand new STEM-related concepts as opposed to what they actually understood these new STEM-related concepts to mean. The surveys also included a question asking, "What do you want to be when you grow up?" For this last question, the results were grouped into three categories for pre- and post-presentation comparison:

- STEM-based careers (STEM)
- Professional Athletes (SPORTS)
- Other (which included "I don't know yet") (OTHER)

The questions in the pre- and post-presentation surveys were consistent within each presentation, although they varied across presentations depending on topic. All students were asked what they wanted to be when they grew up regardless of presenter.

The original assumption was that girls and boys would form different populations with respect to STEM awareness and comfort. It was also suspected there could be differences between children in grades 3 and 4. For those reasons the data were analyzed in 8 sub-groups: Girls in grade 3 pre- and post- presentation; Boys in grade 3 pre- and post-presentation; and the analogous groups for grade 4. In order to compare results, a **response value** (average score) was calculated for each survey based on the average of the ranking answers for concept/vocabulary questions in that survey. The average **response values** for each of the 8 sub-groups are presented in Figure 1.

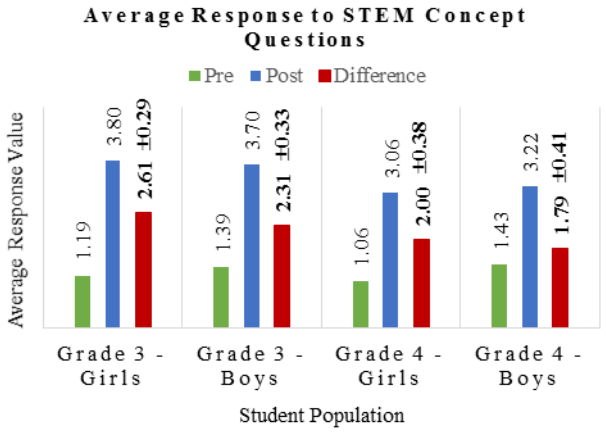

FIGURE 1
STUDENT AVERAGE RESPONSE VALUE FOR STEM CONCEPT QUESTIONS
(T_{CRIT}= 1.98, D.F. ~ 100)

The results show that all groups of students think they know more about the STEM topic after the presentation than before. The data used in Figure 1 can be analyzed to determine the 95% confidence intervals for the differences between pre- and post-presentation response values (note – for analysis purposes all 8 sub-groups were considered independent). This analysis suggests that the change in perceived STEM knowledge from pre-presentation to post-presentation is significant. These results are encouraging because they suggest the SmartKids program can effectively reach both girls and boys across different grade levels. They also demonstrate that boys and girls at this age feel confident they can understand STEM concepts.

"It is undeniable that there is a disconnect, especially at the elementary level, between technologies and companies that exist (or are on the rise) that have potential to change the way we view the world. It is tremendously beneficial for elementary students to learn about these technologies and companies" Jason Chevrier, Principal, Castleton Elementary School, Castelton-On-Hudson New York.

Results from the question "what do you want to be when you grow up?" are shown in Figure 2. These preliminary results show no significant change in career interest for the boys in either grade, and a moderate increase in the percentage of girls interested in STEM-based careers after the presentation versus before, however more data collection is needed to form any concrete conclusions. Moving forward, it is our goal to track this interest in STEM-based careers with the same set of students as they go through elementary school and progress into middle school.

Another interesting fact is the number of boys versus girls who want to be professional athletes (~25% vs <5%). Given the much greater number of male professional athletes featured on television and in advertising, one possible interpretation of this result is as an illustration of the importance of role models. This supports the need of a role model pool for all students that shares similar traits (gender, race, even religion) as the students we are hoping to inspire. This continues to be an intentional goal for SmartKids NY as we identify entrepreneurs to present in the classrooms.

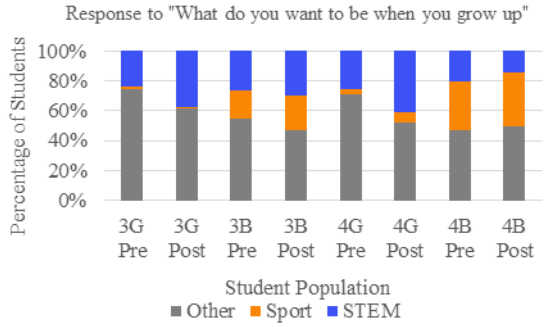

FIGURE 2
STUDENT CAREER INTEREST IN PERCENTAGE

CONCLUSIONS AND NEXT STEPS

The initial data collected clearly shows promising results for the SmartKids program. The next steps for program assessment are to perform a more rigorous determination of efficacy based around our proposed Theory of Change model presented in Figure 3. We assert that the core elements of the SmartKids NY program—the entrepreneur's personal story, hands-on STEM activities, the *Book of Ideas*, and giving teachers and students age-appropriate and accessible content and tools to integrate STEM into the Common Core—will increase students' exposure to a more diverse representation of STEM and STEM-based careers that will ultimately result in more kids forming a lasting appreciation of and self-identification of being STEM-capable as they enter middle school. Data to measure these outcomes will be collected via paired surveys which are currently under development.

Next steps in evaluating the SmartKids NY approach are to follow a cohort of elementary students beginning in third grade through fifth grade and into middle school. Following the same group of students through this critical stage of their education will enable us to directly measure how participation in the SmartKids program may counteract the typical drop-off in STEM interest as described in the introduction [2-4]. Improvements will be made to the current survey design to enable matched pairs analysis and to more fully align with proven instruments that test STEM interest and comfort [11]. The specific pre- and post-assessment tools to be used moving forward have not been finalized. Work with groups at the University of Northern Texas and the College of St. Rose will determine the exact tools to be used.

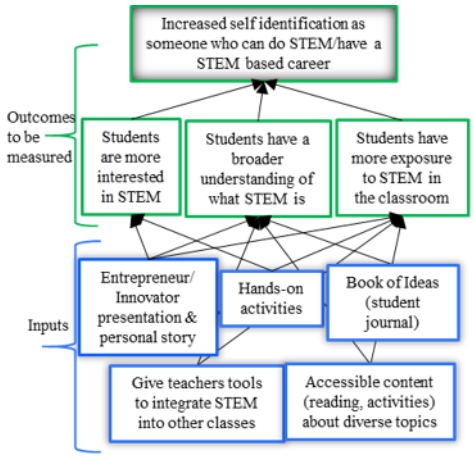

FIGURE 3
SMARTKIDS NY THEORY OF CHANGE MODEL

ACKNOWLEDGMENT

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APPENDIX 1

Example of a set of pre- and post-presentation surveys.

Vital Vio – Pre Survey

1. Are you a girl or boy? Circle your answer: Girl Boy
2. Are you in 3rd, 4th or 5th Grade? Circle your answer: 3rd 4th 5th
   For questions 3 – 5, circle the number on the scale that matches your answer. For example, 0 means you don't know anything about it and 5 means you know a lot about it.

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

3. How much do you know about *Bacteria*?

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

4. How much do you know about *Disinfection*?

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

5. How much do you know about *Wavelengths of Light*?

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

6. What do you know about science?
7. What do you want to be when you grow up?

Vital Vio – Post Survey

1. Are you a girl or boy? Circle your answer: Girl Boy
2. Are you in 3rd, 4th or 5th Grade? Circle your answer: 3rd 4th 5th
   For questions 3 – 5, circle the number on the scale that matches your answer. For example, 0 means you don't know anything about it and 5 means you know a lot about it.

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

3. How much do you know about *Bacteria*?

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

4. How much do you know about *Disinfection*?

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

5. How much do you know about *Wavelengths of Light*?

0	1	2	3	4	5
I don't know anything about this	I heard of this but don't know what it means	I know a tiny bit about this	I know a little about this	I know some things about this	I know a LOT about this

6. What do you know about science?
7. What do you want to be when you grow up?