**WISEngineering Kindergarten Kids: A Feasibility Case Study**

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ABSTRACT

The current research documents findings from a qualitative feasibility case study of a blended engineering design project, *WISEngineering Kindergarten Kids*, implemented by 5 families with their Kindergarten aged children (5 or 6 year olds). Specifically, the study explores the feasibility of implementation, parental and child engagement, and appropriateness of activity level. The study considers similarities and differences in the way parents implement the activity with their children. Educational implications are discussed.

## INTRODUCTION

The current research documents findings from a qualitative feasibility case study of a developmental blended engineering design project, *WISEngineering Kindergarten Kids (WISEngineering Kids),* that blends formal and informal learning, and hands-on and online learning environments. Specifically, the study explores three research questions: 1) Can WISEngineering Kids be feasibly implemented as a take home activity implemented by parents/caregivers with their Kindergarten children? 2) Do parents and children find the WISEngineering Kids engineering design challenge engaging? 3) Is the activity level appropriate for parents/caregivers and children? Additionally, the study considers similarities and differences in the way parents implement the activity with their children, and discusses educational implications.

As a scale-up of the WISE Guys and Gals (WGG) National Science Foundation project, which brings blended learning design challenges to middle school aged learners in informal STEM (science, technology, engineering, and mathematics) settings, WISEngineering Kids builds upon the underlying premises of WGG. These state that children, especially those from groups underrepresented in STEM, will be exposed to and develop engineering design thinking through use of the engineering design cycle, and that exposure to blended engineering design activities will facilitate children's awareness of and appreciation for STEM careers. WGG activities provide learners with opportunities to engage in problem-solving while developing problem-solving strategies and developing habits of mind, or a set of behaviors that are enacted when answers to problems are not known, from an engineering perspective (Chiu et al, 2013; DeJaegher et al., 2012). WGG builds upon a Knowledge Integration (KI) framework whereby learning involves “building upon and sorting out the numerous, varied, and often conflicting ideas students have about phenomena” (Chiu et al, 2013).

WISEngineering Kids extends upon the WGG framework by involving a different population of learners, namely Kindergarten students and their parents or caregivers, and integrating three additional lines of thought. The first line builds upon the theoretical framework of social constructivism (Palincsar, 2005) and family systems theory (Christian, 2006) through which families co-construct knowledge and increasing the knowledge, engagement, and interest of parents and caregivers in specific content areas presents the possibility of influencing the knowledge, engagement, and interest of their children. The second line incorporates the understanding that learning of content and of academic language is enhanced when it occurs in context (Gibbons, 2015). This is a key concept acknowledged in the English Language Arts Common Core standards (http://www.corestandards.org/ELA-Literacy/CCRA/L/) that extends to STEM learning environments (Lee, Quinn, & Valdes, 2013). The third is the understanding that early exposure to social and educational learning experiences increases children’s potential for positive academic outcomes later in life (Howes et al., 2008; Phillips & Shonkoff, 2000).

**Family Systems**

WISEngineering Kids presents blended engineering design challenges for use by parents/caregivers with their children. These activities offer both parents/caregivers and children opportunities to develop the habits of mind of engineers, engage in problem solving situations, and develop their problem solving strategies. Presenting learning experiences that involve parents/caregivers and their children builds upon social constructivism (Palincsar, 2005) and family systems theory (Christian, 2006).

The connectedness of each family member is a key understanding in family systems theory (Van Velsor & Cox 2000) through which the experiences encountered through family situations impacts how family members behave and form expectations for their interactions with others (Christian, 2006; Kern & Peluso 1999; Nieto 2004). The family system consists of interdependent subsystems (Bornstein & Sawyer, 2005; Cox & Paley, 2003; Minuchin, 1985). The theory involves family cohesion, adaptability, and communication (McHale & Sullivan, 2008; Olson, Russel, & Sprenkle, 1980). Families are constructing knowledge together.

Although the family systems model has been largely applied to clinical settings, research in science and language literacy supports the potential of influencing parent and caregivers in order to influence the child. Lonigan and Whitehurst (2008) conducted research exploring the impact of different shared reading experiences on children’s oral language development. In the study, parents and teachers were trained using videos to implement specific interactive reading techniques. Children were then exposed to different conditions (e.g., control, school only reading condition, home only reading condition, and combined home and school reading condition). Children exposed to home reading conditions experienced the greatest effects. Likewise, in a study by DeBaryshe (1995) mother’s reading beliefs positively related to their children’s interest in books. Pingree, Hawkins, and Botta (2000) explored the impact of family communication patterns on children’s science story evaluations, and found that when families exhibited orientation towards concepts in science stories their children in turn thought about science issues when engaging with the science stories.

WISEngineering Kids builds upon the understanding that increasing the knowledge, engagement, and interest of parents and caregivers in STEM and their awareness of STEM careers can impact the influence parents and caregivers exert on the knowledge, engagement, and interest of their children in STEM and their children's awareness of STEM careers. It also supports NAEYC standards for Developmentally Appropriate practice by integrating its key concerns (e.g., learning experiences that crafted through an understanding of child development and learning theories, individual appropriateness, and attention to cultural considerations) (Copple & Bredekamp, 2009) into activity design and revision considerations, and project functioning.

**Learning of Content and Academic Language in Context**

WISEngineering Kids activities provide parents/caregivers and children with the opportunity to enhance their understanding of the content by promoting their academic language development. For example, certain key terms are carried across all activities (e.g., design challenge, specification, constraint, and the various terms associated with each part of the design cycle). Each activity therefore supports learner comprehension of content and academic language skills as learners use key terms repeatedly and in different contexts (Spycher, 2009) and are asked to communicate their design choices and reflect upon key decisions throughout each activity. Research indicates that learning of academic language is enhanced when it occurs in context (Gibbons, 2015, Spycher, 2009, Pollard-Durodola et al., 2011).

Spycher (2009) explored kindergarten children's oral language development through an intentional versus implicit instructional approach. In the intentional approach, Kindergarten children were taught key science terms through a vocabulary intervention in science. Children in the control condition received science instruction but the key terms were not explicitly taught. Findings not only showed that children receiving the explicit instruction learned more of the target terms, but also that these children were better able to express their understandings about the scientific concepts. In this vein, Pollard-Durodola et al. (2011) created a shared book-reading vocabulary intervention in order to help Head Start preschool children develop vocabulary knowledge through their understandings of new words which they connected to concepts in science and social studies.

Therefore, although the project focus is STEM, WISEengineering Kids also addresses ELA Common Core standards, such as applying “knowledge of language to understand how language functions in different contexts to make effective choices for meaning or style, and to comprehend more fully when reading or listening” (http://www.corestandards.org/ELA-Literacy/CCRA/L/) .

**Supporting Early Learning to Facilitate Positive Outcomes Later**

WISEngineering Kids brings STEM learning and awareness of STEM careers to parents/caregivers and their young children in order to facilitate early exposure to social and educational learning experiences. Research indicates early intervention has the potential for increasing children’s positive academic outcomes later in life (Howes et al., 2008; Shonkoff & Phillips, 2000).

Karoly, Kilburn, & Cannon (2005) conducted a literature review to identify evaluations of programs providing early services for children (prenatal though kindergarten). Twenty programs were identified, and considered to have enough evidence of child outcome data to include the program in the study. Nineteen of the 20 programs evidenced positive effects on children’s development. Programs varied in focus, from those that provided parent education, to those that provided early childhood education, to those that combined parent and early childhood education. Longevity of program outcomes varied. However, although some advantages appeared to fade with time, lasting gains were evidenced with outcomes such as grade retention, and high school graduation rates. Additionally, data indicated that the parents of these young children benefited when they were the object of the intervention.

Recent research indicates that children's learning-related skills (including self-regulation and social competence) contribute to early school success. The present study investigated the relation of kindergarten learning-related skills to reading and math trajectories in 538 children between kindergarten and sixth grade, and examined how children with poor learning-related skills fared throughout elementary school on reading and math. Latent growth curves indicated that learning-related skills had a unique effect on children's reading and math scores between kindergarten and sixth grade and predicted growth in reading and math between kindergarten and second grade. In addition, children with poor learning-related skills performed lower than their higher-rated peers on measures of reading and mathematics between kindergarten and sixth grade, with the gap widening between kindergarten and second grade. Between third and sixth grade, this gap persisted but did not widen. Discussion focuses on the importance of early learning-related skills as a component in children's academic trajectories throughout elementary school and the need for early intervention focusing on children's self-regulation and social competence. Moreover, McClelland, Acock, & Morrison (2006) conducted research evidencing the importance of kindergarten learning-related skills and early intervention on children’s positive academic pathways in elementary school.

**WISEngineering Kids**

WISEngineering Kids breaks new ground by attempting to influence children's exposure to and engagement in engineering design challenges by exposing and engaging parents/caregivers in these very same activities with their children. WISEngineering Kids unites the aforementioned lines of thought through a program which provides parents with access to blended engineering design challenges which they then implement with their children. Parents are given the supplies needed for each activity and access to the WISEngineering platform. The online component provides parents with all the information they need to work through the necessary content knowledge and hands on component of each activity. Parents and caregivers of WISEngineering Kids do not need to know the content in order to implement any of the activities. As with WGG, in WISEngineering "the activities are based on the informed engineering design pedagogy, where Knowledge and Skill Builders (KSBs) provide the scaffolding information about the challenge so the youth understand why and what they are doing" (Advances in WISE Guys & Gals). The WISEngineering environment contains all necessary information, as well as links to STEM careers. In fact, each activity links to a particular engineering discipline (e.g., Chemical, Mechanical, Civil) and videos engage viewers in thinking about challenges these engineers consider. Participants in the current study implemented "*SlimeY*" with their children. *SlimeY* engages participants as chemical engineers in the challenge of creating and testing *SlimeY*. Participants are then brought through a spiral learning model where they develop domain knowledge, ideate solutions, build a prototype, then test, evaluate, and refine their design. This process can be implemented multiple times until each participant reaches his or her goal.

Next, we will explore the methodology and results of a feasibility study. Core research questions will be considered.

## METHODOLOGY

Five families provided feedback on the first iteration of the WISEngineering Kids program. All families came from multi-lingual households and all children attended an urban school where at least 40% of the student population is classified as disadvantaged. Each family implemented one WISEngineering Kids activity, *SlimeY*, with their children and had their child create an avatar on the WISEngineering platform. At the start of the program, one parent from each family was given materials for *SlimeY* consisting of borax, glue, and food coloring. This parent was then provided with a logon for the WISEngineering platform, and verbal and written instructions for platform use and avatar creation. Parents were instructed to have their children create an avatar, and complete the *SlimeY* activity following the steps provided in WISEngineering. The parents were also told to explore key platform features for saving thoughts and work (e.g., comments, pics, videos) online through a private journal feature (e.g., *Design Journal*) and for communication amongst families a(e.g., *Design Wall*). One parent from each family then provided feedback about *SlimeY* after completing the activity with their child. Feedback was guided by a series of semi-structured interview questions focused on exploring implementation feasibility, activity level, and parent/caregiver and child activity engagement. and prompts related to the three key research questions after creating an avatar for their child and completing one WISEngineering Kids activity (*SlimeY*) with their children. Prior to completing *SlimeY*, participants were given information about the WISEngineering project, the

WISEngineering platform, and provided with logon information for one child and supplies for one child to complete the activity with their Kindergarten aged child.

## FINDINGS

### Feasibility

All caregivers were able to implement the WISEngineering Kids activity with their children although implementation varied from caregiver to caregiver. All caregivers, except one implemented the activity with more than one child. Caregivers reported bringing in older and younger siblings, as well as visiting friends to take part in the activity. In total, 14 children participated, with two caregivers implementing the project with 4 children, and the remaining caregivers implementing the activity with 3 children, 2 children, and 1 child respectively. Although all Kindergarten aged children were 5 or 6 years old, ages of siblings and friends ranged from 3 to 10 years old.

All caregivers reported viewing the online portion of the activity prior to initiating the activity with their children, noting they wanted to be certain they explained the concepts correctly to their children and would be able to answer their children’s questions. Additionally, caregivers wanted to see what the hands-on portion of the activity would look like and noted researching videos on the making of slime in preparation for completing the activity with their children.

Two families completed the activities the same day and three families completed the activities over the course of several days. While all children participated in the hands-on portion of the activity, and were shown the avatar, caregivers reported that only older siblings were exposed to all the online concepts and questions, with caregivers selectively choosing pieces from the online portion to discuss with younger siblings (e.g., *SlimeY* ingredients). Caregivers reported feeling that younger children would not be able to understand all the online concepts but felt some information was understandable even for younger children. Since all families were only given one logon for their Kindergarten aged child, all families used the avatar selection and entered the question responses of the original Kindergarten aged child when completing the online portion of the activity. Additionally, when friends participated, caregivers reported they only took part in the hands on component of the activity. Families reported using laptops for the online portion of activities, although many noted they would prefer to use tablets or smart devices going forward.

Moreover, three caregivers reported doing the activity more than once with their children in order to revisit the underlying concepts and revise their *SlimeY* designs. Although provided with material for only one child, and one implementation, caregivers reported having the majority of supplies needed for the activity in their homes, and purchasing the remaining supplies which caregivers indicated were not costly. Two caregivers noted extending upon the activity by bringing in other items to enhance their *SlimeY* production (e.g., glitter).

**Engagement**

All caregivers reported that the children found the activity engaging (e.g., “They really loved it.” “They are extremely excited and they want to do it again tomorrow.”) Caregivers stated that the children wanted to do the activity again, and found the activity enjoyable. Two caregivers reported that their children even took their slime to school to show teachers and friends.

Challenges were identified in engagement for the online portion of the activity. However, caregivers reported addressing these challenges by breaking up the activity over a series of days, modifying the language, and bringing in online videos (e.g., "Oh definitely they were engaged and even the little one was grabbing at it – I want to stretch or stir. I have your piece – you have mine. Answering the questions was the tougher part of it. Drag and drop – would work much better for the younger kids – because it's already there for them to see." "We did a little each day for them to answer the questions properly.") Caregivers reported engaging multiple children and that all children were enthusiastic and excited about taking part in the activities (e.g., "They are extremely excited and they want to do it again tomorrow. It's so exciting. [*Child Y stated*] I'm going to go to school. I'm going to tell my teacher. Child Y's teacher is the science teacher. So then he said he's going to show her and tell her how we did it. And why we didn't have the consistency." "I love how it keeps them into it – they were never bored during the whole process. So interesting. After the first one they are already asking when is the second one.")

Additionally, parents reported finding the activity engaging and learning from the activity (e.g., "we don't know there's the kind of this thing. We only let them play with the play dough and squishy things. We don't know this. It's good for them." "Can't say for other kids. I can only say for myself, I would be totally interested in this kind of activity – every other week maybe too much but once a month would be totally doable. A simple kind of activity." "And then this thing called Borax. I kind of – for me it's the first time I experienced it as well – I was as excited as they were – I want to see what's the result, what's going to happen. It's a really fun activity.") Parents identified areas where they came across new ideas, struggled with the activity, but used online resources to look further into the information, and ultimately found the activity "fun."

Moreover, although the online environment offers tools for communication and collaboration, as well as an online journal that is private and where a user can document his or her work and thoughts, caregivers who participated communicated with each other in person (e.g., “ I loved it. Heard from Caregiver X – she said the children seemed like they had so much fun. She even went out and got more stuff – [*I asked*] what other stuff do you need. She got sparkly material, put her own spin on it, and made it more fun for the kids.”)  Some caregivers uploaded videos of their children competing activities to YouTube, although they were encouraged to use the *Design Wall,* a tool built into the online learning environment that allows users to post comments, videos, and pics for all to see. However, caregivers reported using tools with which they were already familiar (e.g., YouTube).

**Level**

All caregivers reported that the activity level was doable with slight modifications. Although, two caregivers reported they were either “scared” or apprehensive prior to starting the activity, referencing lack of prior knowledge or ability to complete the hands-on portion of the activity, these caregivers reported that the activity was doable and enjoyable upon activity completion (e.g., “I was scared I wouldn’t know what to do. But when I started doing it – it was definitely doable and my children loved it. They said thank you.”)

Caregivers reported kindergarten aged children could complete the activity with caregiver support, noting the hands-on portion of the activity was understandable. But, that the language and online concepts required some translation by caregivers so that children could fully understand the concepts. Caregivers reported changing language, showing children online videos, and providing pictures as visual support for the various online concepts. Suggestions for activity development included changing more questions to drag and drop items, or having item responses be visual rather than text based (e.g., picture representations for words) that children might touch to answer questions, and simplifying language. However, caregivers reported that they were still able to do the activity with their children and that both children and caregivers found the activity engaging (e.g., “It’s engaging but at the same token it feels like – there’s a lot of steps that I’m trying to figure it out too as I’m learning it so video would help”.)

## DISCUSSION

Feedback supports the feasibility of parents or caregivers implementing WISEngineering at home with children. Reports indicate that the activity is not only doable, but that the activity can also be conducted simultaneously with multiple learners as a team through the use of one account. Data suggests that the experience could be enhanced through an extended training session where parents and caregivers could be provided with more support in utilizing the offerings of the online environment (e.g., *Design Journal, Design Wall*). Additionally, responses indicate that activity enhancements should include revising activity language to make it more “kid friendly,” revising question items to make them more accessible to younger children (e.g., supporting text with pictures), and either shortening activities or creating pre-defined stopping points to guide parents as they implement the activities with their children. Finally, feedback suggests that including support videos for key concepts and directions in the online platform might enhance the experience for parents, caregivers, and children.

Data supported that the WISEngineering Kids activity was engaging for both children and parents. It also supported that the activity level is appropriate for Kindergarten students when guided through the activities by their parents and caregivers, although slight modifications are needed (e.g., language revision, item enhancements). Additionally, although parents indicated using external supports to enhance their understanding and implementation of the activity, all reported that they felt the activity was appropriate for their families.

Moreover, all feedback consistently indicated high levels of engagement for both parents and children. Additionally, two parents reported the activity bringing them closer to their children (e.g., "Encourage parents to do this type of work because it connects parents with their children and with the children they are working with because they have fun.")

**Implications**

Data suggests that the WISEngineering Kids program is feasible, at an appropriate level, and engaging for parents, caregivers, and children. Next steps include bringing in teachers to connect parents to WISEngineering Kids through their classrooms, and exploring changes in participant (e.g., parents, caregivers, children, and teachers) STEM content knowledge, engineering design thinking, awareness of and attitudes towards STEM, and connectedness.

Every family that participated, except one family, involved older and/or younger children and friends with parents supporting children as they engaged in each step of the activity. Families found the WISEngineering platform easy to navigate, although they had suggestions for activity improvements. The program presents a way to bring parents and caregivers together as collaborative learners of STEM. The program brings parents and learners together in a developmentally appropriate and socially and cognitively stimulating activity

WISEngineering Kids presents a way to expose parents to engineering habits of mind, stem careers, and key stem concepts. This program presents the possibility of influencing parental learning and attitudes towards STEM and STEM careers so they in turn can influence their children's learning and growth regarding STEM and STEM careers.

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