Grant Application: Early Childhood STEM Interactive Technology Education (ECSITE) Project

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Project Summary

Early Childhood STEM Interactive Technology Education (ECSITE)

Overview. The Early Childhood STEM Interactive Technology Education (ECSITE) project seeks to use interactive software to educate pre-school children (ages 3 to 5) about STEM oriented subjects using spatial concepts. In this “fun” project for preschoolers, a Spatial Intelligence Package (SIP) will be developed for preschoolers and available to them via the web on the ECSITE web page. SIP will be developed in the first year, during which consent for research will be solicited as well as other research planning efforts. In the second year of the project, SIP will be administered to 20 preschoolers over 12 weekends mimicking a regular academic term. Their performance skills will be tested at various stages; at the beginning, halfway through the session (after 6 weeks) and at the end (at 12 weeks), to monitor their progress. This project aims to develop in children spatial intelligence skills which is useful for a STEM future. By strengthening spatial skills, children's performance in STEM concepts will be increased. SIP provides a visual heavy yet friendly atmosphere for leisure learning in children. Easy enough to find natural interest, yet engaging enough to stimulate learning.

Intellectual Merit. SIP will provide an avenue for which children can mindfully use technology to supplement their classroom education in their leisure time. Alternatively, it is a good entry tool for children who are not enrolled in typical preschool programs (are homeschooled). It confirms academic material by drawing on proposed curriculum concepts that preschoolers should learn before entry into K-12. It will also provide a diagnostic comparison model to confirm relationships between time spent on SIP and performance improvement. There is currently an underrepresentation of populations from developing countries, especially females, in global STEM disciplines. This is driven by many factors, one of which is knowledge inaccessibility. This two-year project will demonstrate that STEM education can be introduced as early as the preschool years, and spatial intelligence is a good avenue to do that. There have been studies tracing success in spatial intelligence to success in STEM disciplines. Since this study will be carried outside the USA, it will also demonstrate that these success traits are universal and without cognizance of socio-cultural factors.

Broader Impact. Other forms of media such as text books, toys and cartoons have been used to stimulate learning in young children. SIP will harness the *pedagogical content* in books, the *manipulable fun* of toys and *audio-visual properties* of the cartoons to provide an *exciting* introduction to STEM. The software could also be expanded to more advanced spatial skills, math and related skills that will be useful to the preschooler in later education. One way to know what a child likes, what a child is good at, is by exposing him or her to these skills in the earliest and least intimidating setting possible. This kind of immersive learning can develop a propensity for excellence in later life in STEM related disciplines.The formative model of this project allows an introspective and niche study into early childhood education. By using current tab devices, it encourages the creative use of technology for education in a conscientious way. It is expected that the children will be more enthusiastic about learning and will understand learning not just as an activity that occurs in the classroom but is non-geographically situated.

B. Project Narrative

a. Significance

They are into legos and play dough, or maybe cartoons and tea parties. The perks of being a child, rife with such wonder and curiosity. Their litany of questions rivals an attorney's. At ages three to five years, the child is cognitively a sponge, absorbing all and sundry knowledge. This is a prime time to expound upon the child's spectrum of intellectual abilities or *multiple intelligences*.

Robert Gardner first put forward the theory of multiple intelligences in his 1983 book, *Frames of Mind*. The theory holds that human intelligence isn't measured by a single quotient but rather differentiated into seven distinct groups that capture more broadly the range of human potential (Gardner, 1983). These groups are, namely;

- visual-spatial : space, imagery
- verbal-linguistic : words, language
- logical-mathematical : abstraction, numbers
- bodily-kinesthetic: fine and gross motor skills
- musical: rhythm and sound
- interpersonal: socialization
- intrapersonal: introspection

ECSITE (Early Childhood STEM Interactive Technology Education) considers these intelligences as pathways to scholastic achievement in STEM disciplines. It aims to use technology to develop these pathways in preschoolers. The focus here in this project is on just one of these pathways, visual-spatial. This grant seeks to develop a Spatial Intelligence Package (SIP) suitable for preschoolers. SIP will be a four module package, with each module addressing each of the four areas of spatial intelligence put forward by the National Science Foundation (NSF) funded Spatial Intelligence and Learning Center (SILC). The areas of spatial intelligence, in no particular order are; Intrinsic-Static, Intrinsic-Dynamic, Extrinsic-Static and Extrinsic-Dynamic (Newcombe & Shipley, 2015).

Intrinsic-Static

This refers to the unchanging properties of the objects that identifies them as belonging to particular groups e.g. their size, pattern, shape etc. An activity in this category will be solving puzzles with cues from a picture template

Intrinsic-Dynamic

These are the manipulable properties of objects without altering their original dimensions e.g. folding along a diagonal, rolling a ball, rotation of a circle. Lego is a well-known tool with intrinsic-dynamic properties. It allows children to build a wide variety of structures .

Extrinsic-Static

These are the unchanging properties of the objects that differentiates them spatially from other objects e.g. taller than, wider than, near, far etc. Toys that depict these properties are often miniature replicas of real world spatial structures. An example is a barbie doll house, a map of the globe, a three dimensional maze

Extrinsic-Dynamic

This refers to the complete motion of objects in a scenic environment e.g. animation. Items in this group combine all of the other properties. Building a train track for instance will belong here as will motion-sensitive games like the Nintendo Wii.

The proposed timeline of ECSITE project will begin with research planning and software development efforts. This will be succeeded by the actual implementation of the software and in-house testing to make sure it is error-free. The pilot group of twenty parents and their preschoolers will then undergo a twelve week study session, during which the preschoolers will be subjected to a series of basic concepts assessments. From this overview, it can be concluded that the project will concurrently run two streams, that of academic-research oriented activities as well as operations-production activities. In the sections that follow, more information is detailed about the project's phases.

Phase One : Initiation (At 0 – 6 months)

The first phase of the project signifies the commencement of the ECSITE project. In this stage, the idea is developed more fully of what should be accomplished by the end of the project. This involves writing a proposal, soliciting financing, feasibility studies and expected results.

The deliverables at the <u>end</u> of this project are:

- **SIP**, a working open source software application available to selected accounts via a website. This application is an educational effort towards familiarizing preschoolers with spatial concepts via on screen objects that can be manipulated digitally. It will use a storytelling, fun, adventurous approach with elements assimilated from their real life formal and informal play-learning environments
- A **technical report** that documents the processes and progresses encountered from the beginning to end of this project, addressing if the objectives were met, problems encountered, results and insights for future work of this nature

Phase Two: Development (At 6 – 12 Months)

The development phase of this project will require acquiring personnel, setting up the physical environments for the project, soliciting co-operation from project partners and personnel, setting up a logical structure, selecting the research population and basically, setting up the foundation for the project to succeed. This phase lays emphasis on the operations-production streams of activities; at its core is the development of SIP until it is ready to ship. The software development process involves;

- Software Analysis: produce a working plan of elements that SIP should contain based on ethnographic and pedagogic information collected in *Phase One: Initiation*
- Software Design: generate sketches, mockups and a digital prototype showing SIP's visual interface
- Software Coding: combine the analytic and design information into a working web application by the programmers
- Software Testing: ensure that SIP is fully functional and error-free
- Software Integration: deploying the application to the web and providing access via authenticated accounts

Phase Three: Execution (At 12 – 18 Months)

This phase will dwell on the academic-research stream of activities. The pilot group of twenty preschoolers are selected with consent from the participating parents. The participants will be required to be at the training center three times during the twelve week study session in this phase; the orientation, intermission and conclusion.

During the orientation, the iPads are distributed to preschoolers and accounts are created for SIP access on the ECSITE webpage. The parents are taught the iPad basics; how to charge it, turn it on or off, connect to the internet, launch the browser and access the SIP app (including the user guide, help menu, FAQ section). The children are given their first assessment based on Boehm's Test of Basic Concepts: Preschool Version (Boehm, 1986). Both parents and children are shown how to interact with SIP and allowed to explore until they express familiarity with the application. They are allowed to use SIP at home for the following twelve weeks. For the purpose of the project, these are the usage limitations;

- SIP will only allow one account per user and one user per household.
- SIP will collect non-identifying demographic information and diagnostic usage data
- SIP will be available only during the weekends (12:00am Saturday to 11:59pm Sunday)
- SIP account access will be valid for only twelve weeks

The intermission period offers an avenue to reconnect with the project team and address any ongoing concerns at the training center. This will be between the sixth and seventh week of the session The same Boehm's test is administered at this time and once more during the conclusion after the twelfth week. The participants can also opt to provide information about their session experience and recommendations for improvement.

Phase Four: Synthesis (At 18 – 24 Months)

The synthesis phase requires making sense of all of the information that has been captured (ethnographic, pedagogic, diagnostic) at the end of the study. In this phase, the technical report which has been slowly built up from the previous phases is finalized.

PROJECT TIMELINE

The project is expected to take place over the course of two calendar years, between the first of January, two thousand and seventeen to the thirty-first of December, two thousand and eighteen. The proposed timeline of previously detailed activities is shown below;

Phases	Activities	Duration
Phase I: Initiation	Project Definition	January - June 2017
Phase II: Development	Research Planning	July 2017
	Software Development Process	

	Analysis	August 2017
	Design	September 2017
	Coding	October 2017
	Testing	November 2017
	Integration	December 2017
	Research Implementation	January - June 2018
	Study Session (SS)	
Phase III: Execution	SS : Orientation	April 2018
	SS: Intermission	May 2018
	SS: Conclusion	June 2018
Phase IV: Synthesis	Project Evaluation	June - August 2018

INTELLECTUAL MERIT

There have been several discussions in literature regarding the propriety of children and adolescents' utilization of pervasive technology such as personal computers and mobile devices. Contemporary studies have dimmed that discussion by showing that when used conscientiously, technology can be beneficial to children (Yelland, 2005). Therefore, future research should steer the debate from *what* these benefits are towards the *how*. *How can children, in this case, preschoolers further assimilate these benefits? How do these benefits accrue longitudinally? How will these benefits impact the practice of early childhood education?*

In an ideal world, all children will be able to access the technological and pedagogical benefits but due to several limitations both internally (with respect to the child in particular) and externally (with respect to the child's circumstances), this hasn't been so. For example, mathematical aptitude for all ages, early childhood notwithstanding, is a seemingly plausible goal. However, those with economic and social disadvantages are handicapped by knowledge inaccessibility stemming from early childhood(Cross, Woods, & Schweingruber, 2009). Additionally, some gender-performance correlations were discovered during a spatial skills assessment with the males outperforming the females (Hill, Corbett & St Rose, 2010). Though these correlations were not apparent in early childhood, they peak dominantly at about age 10 – 18, and continue well into later years (Johnson & Meade, 1987). A similar phenomenon exists in STEM professional practice with an underrepresentation of females (Hill et al., 2010).

According to Diezmann and Watters (2000), also ascertained by Wai, Lubinski and Benbow (2009), spatial skills can reliably predict the pursuit of and performance in STEM disciplines. For this reason, SIP can be viewed as an early stage technological intervention for the aforementioned less than ideal prognosis. The outlook is promising based on empirical evidence. Consider this study of 41 children aged 3 to 6 by Couse and Chen (2010). They observed that despite initial technical difficulties, these preschoolers had a keen interest in tablet devices that increased with age and persistent usage. Similarly, Newcombe (2010) noted that children "showed substantial improvements in spatial skill from a wide variety of interventions, including academic coursework, task-specific practice, and playing computer games that require spatial thinking..." (p. 31).

Szechter and Liben (2004) videotaped parents reading a children's story book *zoom,* filled with predominant spatial language and representations such as maps and photographs, to their children. The children were then tested on their ability to complete two related tasks to the book just read; it included ordering objects in sequence and pairing similar objects that were randomly dispersed, one from the other.When the data was coded and analyzed, there was a peculiar link between measures and performance of spatial-graphic dimensions.

BROADER IMPACTS

The reviewed literature above gives credence to the elements of the SIP software. The impacts are addressed three-fold:

How will the preschoolers assimilate the benefits of SIP?

SIP will utilize rich imagery in it's design. The application will incorporate familiar objects from the children's real world environment; homes and classrooms. Using storytelling and adventure to teach children mathematics has proven to be effective (Casey, Kersh & Young, 2004).

A study by Clements and Sarama (2002) shows that "Children who use practice software about ten minutes a day increase their scores on achievement tests." Through the initial orientation and subsequent practice with SIP over twelve weeks, the preschoolers' familiarity of the application will increase as will their technological and pedagogic competencies.

How will the benefits of SIP accrue over time?

This is really more a question of numbers. SIP has a component that will collect diagnostic usage data. When this data is matrixed with demographic information and scores from the Boehm's test, it will provide descriptive insight. This quantitative approach comes on the heels of a related study that had success using qualitative measures of spatial performance (Szechter and Liben, 2004).

SIP's diagnostic tool is also a built-in incentive to experiment with a larger pool of participants and across other multiple intelligences' pathways.

How will SIP benefit the practice of early childhood education?

Casey, Nuttall and Pezaris (2001) believe that intervention introduced early enough children will diminish the gender inequality in later scholarship performance. As a learning tool, programs like SIP have also aided the comprehension of spatial concepts (Clements & Sarama, 2002; Newcombe, 2010).

Thus, if SIP is at the very least, minimally beneficial, gender-performance correlations on the spatial aspects of the Boehms' test should be negligible. This will champion a gender-neutral approach to nurturing spatial skills in early childhood settings and consequently perhaps, increased female interest STEM disciplines.

b. Method

The SIP academic-research stream will use a descriptive-quantitative design. Twenty preschoolers and twenty parents or guardians will participate in a twelve week long study session during which they will interact in their homes with the SIP application via mobile web-enabled tablets. These preschoolers will be selected at random from a single private school in the capital city of Nigeria, Abuja. This school provides education to about four hundred students from preschool through to senior high school. The preschoolers will be accessed prior to, during and after the session.

Research questions

1. Does the performance on SIP improve with usage?

SIP has a feedback component that automatically collects usage data for each account such as login time, performance on various levels/modules of the application, frequency of use and the like. This also looks at the diagnostic data collected from the web every weekend as the children interact with the application. It looks at time spent on the application as well as their results on the four domains of spatial intelligence.

2. Does the performance on spatial tasks in the Boehm's test improve over time?

This compares the scores from the three continuous assessments administered. It will look at the intermittent and gross changes in performance.

3. Is there a relationship between the performance on SIP and performance on the Boehm's test?

The data collected from research questions *1* and *2* above are examined for correlation.

4. Is SIP a beneficial tool for improving spatial and basic concepts skills?

Descriptive insight will be deduced from the outcomes of research questions *1*, *2* and *3* above as well as feedback from the participants.

Rationale for method

Boehm's Test (1986) is a validated instrument for collecting information on preschool readiness. Using this ensures emphasis on reliability and validity of the data.

SIP provides a tool to automatically collect diagnostic and usage information. This ensures accuracy in measurement as well as objectivity where, otherwise, self-reporting will be biased or observation, cumbersome.

c. Personnel

The following members of the team have the pre-requisite programming and research experience for a dual-streamed project of this nature.

Japari Ngilari (Lead PI)

Japari is a doctoral student in learning technologies at the University of North Texas. She also works as as an instructor in the department of computer science and software engineering at a private university in her home country and site of the project, the capital city of Nigeria, Abuja. She has both Bachelor and Master of Science degrees in software engineering from the American University of Nigeria and University of Manchester, United Kingdom, respectively. She has worked in various capacities as developer and project manager in the technology industry prior to her foray into academia. Because of her backgrounds in programming and research, she will be able to effectively spearhead this project. She has published papers in peer-reviewed local and international conferences on the subject of technology use. Her interest in this project is driven by a gap observed in a recent research project. She observed the limited number of publications on early childhood education in Africa, especially regarding technology use. Outside of corporate studies, empirical research was lacking. A project like this could fuel literary discourse. Her involvement will provide an avenue for collaborative undertakings with other researchers and industry professionals. She has a 50% involvement in this project.

Agbor Aln (Co-PI)

Agbor is the Co-PI on this project. He is currently a senior developer and project lead with the renowned software company, Google. He is also a founding member of the team behind the Google for Education initiative. In his capacities, he is chiefly concerned with designing interactive software and improving the web user experience for children. He has Bachelor of Science degree in Psychology and Early Childhood Studies. He obtained his Master of Science degree in Logic, Computation and Methodology from Carnegie Mellon University's Department of Philosophy. He is a Google ambassador to Africa and has successfully liased several educational technology projects in the continent on behalf of the company. In his spare time, he runs a popular educational technology blog under a pseudonym. He gets at least 120, 000 visits from all over the globe to his blog every month. His academic foundation with children is much needed in this project as well as his technical writing experience and industry connections. He has a 25% involvement involvement in this project.

Kivi Alex (Programmer)

Kivi Alex is a programmer on this project. He will be responsible, alongside Salana Vanara for all aspects of the Software Development process as supervised by the Lead PI, Japari. Kivi is a freelance programmer and has developed several open source applications. He has also worked previously with the Co-PI, Agbor, on a website that provides teaching materials for elementary school teachers in Nigeria where he currently resides. He has a 12.5% involvement in this project.

Salana Vanara (Programmer)

Salana Vanara's background was originally in finance, with a Bachelor of Science degree in International Accounting from the University of Suffolk, United Kingdom. She is self-taught as a programmer, taking part-time classes at the University of Manchester while she managed the department of sponsorships and scholarships at the same institution. She now owns her own higher education software development company SalVan Systems Limited while consulting on several projects for the Nigerian government. She also organizes an annual technology startup conference that has hosted prominent guest speakers such as Bill Gates and Mark Zuckerberg. She has a 12.5% involvement in this project.

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