



Journal of Business and Social Science Review  
Issue: Vol. 1; No.9; September 2020 pp.1-11  
ISSN 2690-0866 (Print) 2690-0874 (Online)  
Website: www.jbssrnet.com  
E-mail: editor@jbssrnet.com

## **Engaging University-Business Partnerships to Sustain and Improve STEM Education in K-8 Schools and Develop Teacher Leaders**

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### **Abstract**

University-Business partnerships for education can provide a wealth of benefits for STEM education, not only to those involved in the program itself, but to those who employ teacher candidates who have been involved in the process. This study discusses the benefits of a partnership between LEGO Education® and High Point University School of Education and how it has expanded over time. The university program contains five components that work in conjunction with the partnership, the community, graduate and undergraduate students, parents, and schools. Data suggests that the benefits of the partnership are quite expansive in all five areas. STEM literacy is of great need in America, at a time when there is also a creativity crisis. Partnerships such as this can help fill the gap and better prepare STEM teachers and students of the future.

**Keywords:** (STEM, STEM Education, Partnerships, Business-University partnerships)

### **Introduction**

Instruction through STEM integration is powerful and could be the catalyst to raising test scores and narrowing the creativity crisis that exists in the United States. According to Chesloff (2013), Young children are natural born scientists and engineers if we provide them with the tools to create. Research from the University of California, Irvine (Duncan, 2013) confirms that early math skills are a better predictor of academic success than early reading skills, so why are we not using STEM competencies to boost learning? Providing teachers with strategies, materials, and training in the use of new and innovative resources is crucial. STEM is not just about using Science, Technology, Engineering, and Mathematics together, but using these content areas as ropes to tie learning together serving as the integration piece in instruction. With the initial development and use of Common Core, Essential Standards, and the Next Generation Science and Engineering Standards; it has become evident that the old ways of textbook teaching and vocabulary building exercises are no longer relevant to students in classrooms across the country. Encouraging students to “think critically and conceptually” about math, for example; is now the number one priority in the math classroom! This endeavor is difficult on the part of teachers who were not trained in creativity and critical thinking processes and methodologies.

Teachers need to be able to utilize strategies that engage and motivate students in the areas of science, technology, engineering and math; while principals and instructional leaders everywhere continue to eliminate science and social studies from the school day. One way to insert innovation into the math and STEM classrooms in America is through partnerships with businesses. This can take place at any level of education but can provide immense benefit to all involved. “When companies and universities work in tandem to push the frontiers of knowledge, they become a powerful engine for innovation and economic growth” (Edmondson, G, Valigra, L.; Kenward, M.; and Hudson, R., 2012). Many businesses have expressed concern about the lack of creative graduates that American schools are producing for the workforce of the future. IBM conducted a Global CEO study of 1541 general managers and CEO’s in America in 2010 that revealed the point that businesses felt creativity to be the most critical factor for future success of those seeking employment.

Given the fact that for one to be successful in the business aspects of the global world, there is a need for adequate use of the twenty-first century skills of Collaboration, Communication, Creativity, and Critical Thinking this study rings true. These skills are found in classrooms where students are able to think about learning, reflect, and work with peers These skills are not found in the drill and kill of workbooks, and rote learning.

Strategies that enhance the conceptual understanding of mathematics as it relates to STEM are a necessary component of today’s teaching and learning environments. It all begins with teacher preparation programs and universities that prepare our future teaching force.

Given the fact that curriculum is changing; coupled with the aging of the current teaching profession; it seems that educational change has to begin with pre-service teacher education programs. One such innovative change is taking place in North Carolina at High Point University where the teacher education program focuses in on STEM integrative methods of teaching and learning. STEM education is lacking in public schools in terms of true integration and must begin with the training and development of newformats of teaching methodology. Pre-service candidates at High Point University learn how to use exemplary programs through campus initiatives that reach out into the community of veteran teachers and students surrounding the university and throughout the state. In this teacher education program, teacher candidates work with LEGO® Education Systems as a primary partner. Candidates then utilize this learning through an initiative entitled, Come Build with Us at HPU! Students from area schools are invited into the School of Education Lab to build, design, and create through STEM activities that enhance mathematics, literacy, engineering, and social sciences. The purpose of this research is to continually investigate the degree to which a sustainable University-Business partnership is possible, as well as the impact said partnerships might have on pre-service teachers, businesses, university programming, schools, communities, and students that participate in the process.



**The Program Partnership and Data collection**

The Come Build with Us at HPU partnership has multiple layers that have been developed throughout the eight-year partnership process. Table 1 summarizes these layers in order to give a full understanding of all the parts the two entities (LEGO© Education and HPU) worked through.

Table 1: Partnership Layers

Year	Program Piece Developed	Targeted Audience
2011-2012	Field Trip Program Initial year	Junior Level Teacher Candidates Local schools
2012-2013	Community Showcase for LEGO ED	All parents, community leaders, and Children , All junior -senior pre-service teacher Candidates in School of Education
2013-2014	Executive Model for Business Training	LEGO President, Sales reps and leaders From the business. Graduate students, Professors within the School of Education
2014-2015	Teacher Academy for LEGO ED	Graduate level candidates, teachers From the area and state.
2015-2016	STEM Summer Camp	Graduate STEM Candidates Local Schools

**Field Trips**

The field trip program began as an afterschool project in two schools in the local area to enhance the love of science and help close the gap for English Language Learners and females. While no data was taken other than numbers of participants in the first two semesters, evidence suggested that the program needed to be expanded to include more schools.

Table 2: Attendance Over Time Come Build with Us Field Trips

Year	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
N=	970	1,165	1436	1843	1850	1862	1871

The partnership with LEGO© Education Systems continues to grow and is in its eighth year. After each event a teacher survey is issued via Survey Monkey in order to gather quantitative data for the purpose of making future events better. The data indicates positive results for the program in four key areas: creativity, standard alignment, engagement, and learning for students.

At the end of fall 2016, all data was analyzed and compared. Teachers responded with a 76.92% rating that all the activities fostered creativity among students who attended the field trip, 61.54% of the teachers felt that the activities were well aligned to content standards and engineering standards; 92.31% of teachers responded that the use of LEGO© Systems activities had a positive impact on student learning and engagement. This points to the need for better alignment between content and activities, which has been addressed with the addition of the “Brick Math Series” in 2016-17. Schools are asked to provide standards that they prefer be aligned for their particular field trip experience, however, often times schools do not comply, and topics are chosen and aligned to the standards chosen on- site which may not be in the content area that the teacher is working at the time of the field trip.

**Showcase Event**



A second layer was created to expand this outreach to the community. A showcase event was created whereby local community members could bring children to participate in a Creativity Showcase with LEGO Education in the School of Education. The first event brought out over 500 people. To date over 10,000 people have attended these events. The event was initially held twice a year (November (Session 1) and April (Session 2) however, in 2018 it was decided that beginning 2019 the event would move to one session a year due to the large numbers of attendees and the number of hours of set up required. This decision was also made in part because the University wanted the program to become part of the annual Christmas Event which brings in 20,000 people each year. STEM pre-service candidates and graduate STEM Education candidates set up activities for the event, conduct parent workshops, and teach the lessons to children, then analyze the data taken from the events.

Table 3 shows the number of community people who have attended since the inception of the community event program. This data shows a marked increase in the numbers until 2018-2019. The numbers for 2018-2019 were smaller due to the move to one Showcase event. The numbers that attended the Christmas event however surpassed the overall expectations for a second Showcase.

**Table 3: Attendance by years Community Showcase Event**

Year		Attendees by Session		Totals by Year
		Session 1	Session 2	
2012-2013	Children	250	85	
	Adults	422	170	
	Total	672	255	927
2013-2014	Children	183	190	
	Adults	375	445	
	Total	558	635	1,193
2014-2015	Children	185	265	
	Adults	380	554	
	Total	565	818	1,383
2015-2016	Children	400	435	
	Adults	525	572	
	Total	925	1007	1,932
2016-2017	Children	450	470	
	Adults	570	660	
	Total	1020	1130	2,150
2017-2018	Children	550	557	
	Adults	725	770	
	Total	1275	1327	2,602
		Total Served		10,187

2019-2020 was scheduled for April but was cancelled due to the pandemic Data from parent surveys is also continually analyzed to help improve the event each time. This data can be seen in table 4 below. Parents were surveyed on two aspects of the event: perceptions and expectations; and content and learning. Table 4 shows the overall data from 2013 –present based upon a 5-point Likert Scale mean. Table 5 indicates the degree to which parents felt that the event was relevant in the area of content and learning.

**Table 4: Parent Survey Data *Event Perceptions***

Year	N	Organization of Event	Prior Expectations Met	Likelihood of Future attendance	Parent Workshop
		$\mu$	$\mu$	$\mu$	$\mu$
2013-2014	241	4.66	3.24	4.50	4.00
2014-2015	389	4.82	3.95	4.71	4.89
2015-2016	530	4.91	4.50	4.77	4.89
2016-2017	625	4.92	4.90	4.90	3.78
2017-2018	690	4.95	4.90	4.90	3.66

Table 5: Parent Survey Data *Content and Learning Demonstrated by Event Activities*

Year		Creativity Demonstrated	Scientific Thinking Demonstrated	Support & Encouragement	Content Knowledge & Preparation
	N	μ	μ	μ	μ
2013-2014	241	4.56	4.50	3.57	3.86
2014-2015	389	4.95	4.86	3.85	4.25
2015-2016	530	4.96	4.68	4.33	4.35
2016-2017	625	4.95	4.90	4.38	4.45
2017-2018	690	4.95	4.92	4.45	4.65

This data indicates that overall the program has grown in content and learning since 2013. Parent workshops were added as an additional component in year 3 so that parents could better understand ways that they could help their children with creative learning in STEM. Parents are eager to play a part if we tell them what they can do to help in most instances. This addition to the program has created an opportunity for additional schools to get involved as parents take the information back to schools and share what they learned. The feedback from parents about this event has allowed the showcase program to expand and grow over the 5 years it has been in existence. Looking at the parent data for perceptions and expectations it seems that the showcase event was exactly what they had anticipated. While not all adults completed the survey, enough data was gathered to lead us to a rearrangement of and addition to activities utilized for the event. The more people the more crowded so we moved to a larger space and added additional activities. This was a suggestion added to the survey by about 25% of the parents completing the survey. The comments from parents included items such as: “This was truly an inspirational event”; “This event is better than going to LEGOLAND!” which were very inspirational to the teacher candidates and allowed them to see how informal education can be beneficial.

Table 6 shows student participant data across years. Students completed the survey following the event if they wanted to provide feedback.

Table 6: Student Data Showcase Event: Comparison over years of data

	2013-2014 N = 150 μ	2014-2015 N = 171 μ	2015-2016 N = 350 μ	2016-2017 N = 470 μ
Q1: LEGO helps me understand Math	3.25	3.67	3.75	3.80
Q2: I learn best when I build models for math and science	3.40	3.87	4.12	4.25
Q3: Using LEGO makes me want to learn math and science	3.50	3.86	4.25	4.25
Q4: LEGO helped me Problem solve	3.25	4.14	4.40	4.50
Q5: Learning with LEGO builds my confidence about learning	3.25	3.86	4.45	4.50

The data indicates that students continue to see LEGO® Education Systems for Learning as advantageous and that they enjoyed learning content in this way. The content they were exposed to included Robotics, Storytelling with the Brick, Math with the Brick, Coding, Engineering Race Cars, Problem solving, and Creativity. All areas saw increased means across the years. The stat for 2017-2018 was available due to technical difficulty at the event that year.



### **Executive Model**

During the year 2013-2014, the President and CEO of LEGO® North America worked with the University to create an executive model for those involved in the sales to participate in a week-long training session about educational technology, curriculum, awareness of teacher perspectives, school mindset and the organization of school. While this was well received, it was decided that we would not continue this piece of the programming due to funding. Those who participated found it rewarding in that first year and has been discussed for a later time. One part of this model that did materialize and provide great benefit to both the company and the pre-service teachers was the opportunity to participate in the development of a new product. Seeing product development from inception to shelf was rewarding for the candidates and helped the business partner see the need to involve teachers in the development conversation.

### **Teacher Academy**

The business partnership with LEGO Education® has provided teacher candidates greater and more varied opportunities in the workplace. Businesses, teachers and principals from around the area are seeking out these pre-service candidates and graduate candidates as new-hires to help integrate STEM into the classrooms of local schools and in non-profit organizations. It is evident that the desire to utilize STEM ideology is prevalent, but the investment in teacher training within the schools is not evident. These pre-service and graduate candidates have the opportunity to work alongside certified LEGO® Education Trainers in the High Point Teacher Academy, which was developed as layer four in an effort to expand their knowledge, therefore can be teacher leaders in the new schools in which they become employed. The Teacher Academy for LEGO® Education offers training for local teachers once each month and has served over 600 teachers since it began in 2014. The partnership with LEGO® Education Systems allows teachers in schools that do not have the funds to hold their own LEGO® training to send one or two teachers to the academy for a train the trainer model. Students at High Point are allowed to attend the sessions free of charge, affording them the opportunity to bridge the STEM gap in their future schools.

## STEM CAMP



In the 2015 school year, the fifth layer of the Come Build with Us program was introduced in the form of a summer STEM camp. The camp initially offered 53 students ages 8-11 the opportunity to experience STEM in a hands-on way, and pre-service teachers the opportunity to serve as teacher leaders. Building teacher leaders for tomorrow's classrooms is a key aspect in the overhaul of America's educational system. The 2016 camp added 6 children and the 2017 camp is set for 68 students. The camp from 2019 included 150 children ages 8-12. In 2020 the camp took on a new feel due to the pandemic and became HPU STEM Camp in a Box. It served 150 students across the United States. Data is currently being analyzed to ascertain the degree to which the later program was successful. The data gathered from graduate students in the years leading up to 2020 indicate that students feel they learn more from discovery, problem-solution finding, engineering design and robotics than from other forms of activities. Students commented that they wished school as like this because they could learn so much more. This is a testimony to the degree to which informal educational settings impact student mindset about learning.

The current partnership with LEGO® Education Systems has allowed pre-service and graduate candidates to be a part of understanding how materials get from inception to the shelf, how it is tested with children, and how to look at materials critically. Lego Education Systems® is one resource currently creating a stir in educational classrooms across the country. Lego® Systems of Learning offers students the opportunity to experiment with their surroundings to expand existing knowledge. This system of knowledge is primarily about building onto a currently existing knowledge base, not necessarily creating new content. Pre-service and graduate candidates alongside LEGO Education Specialist and Curriculum Designers from both Denmark and the US gathered at High Point University to investigate the needs of new teachers who may want to use LEGO® in the classroom but not know how to get started.

Those University-Business conversations have sparked a new major at HPU in Education Studies that can be linked with a business degree or other areas such as human resources or entrepreneurship for those wanting to pursue an educational business in the future.



## **PRODUCT VARIANCE**

LEGO® Education is constantly updating products, thereby removing products from the market that they feel are underutilized in schools. The current partnership began with many of such products and is now shifting with the market. Products like More To Math, Story Starter, and Build to Express are examples of products that have been removed from the market. In the field trip programs Story Starter and Build to Express are still utilized. New products like Spike Prime and Coding Express are making their way into the research agenda for the partnership.

Products like LEGO More To Math® helped build a love of math for students in grades 1-2 that leads to a better understanding of mathematical practices. Data (600 data points) taken regarding MoreToMath for grade 1-2 indicates that significance exists ( $p < 0.05$ ) with the use of the program in first and second grade classes. Pre –and- post assessments show an average of 5-7 points for children using the brick to learn math as opposed to those using more traditional methods. Math is an area whereby students appear to be struggling in the United States. This more creative methodology is seeing success in the High Point program and schools in the area. This product was removed from the market in 2015. The use of this product has since been replaced by another brick program not part of the LEGO® product line. Teaching Math Using the LEGO Brick®, which is part of the Brick Math Series, allows students in grades K-8 to explore the critical and creative nature of conceptual mathematics. Research shows that students utilizing this strategy are better able to explain, write, and understand math concepts. Ongoing research with the Brick Math Series is underway. Though this is not a LEGO Education product, the author of the series and the publisher are partnering with teacher candidates to analyze the product and gather feedback about how it works in K-8 classes in the area. It is based upon the same system for learning as LEGO Education®, therefore is a good match for the current projects. Test sites at 4 elementary schools using students in grades 3-5 are reporting great pre-and- post assessment results.

Significance in areas of engagement and time on task as related to performance is being noted ( $p < 0.01$ ). The current study, though not complete, includes the data from 534 students in rural, suburban, and inner city areas (N= 240 rural; N = 140 suburban; N = 154 Urban) of the students participating in the study, 100 of them are using the multiplication materials in grades 3 and 4; 125 are using the division materials in grades 3 and 4; and 309 are using the fractions materials in grades 4 and 5. The average gain from pre-test to post-test is 7-9 points for those utilizing the brick versus more traditional methods using the fraction materials in grades 4 and 5 (N = 309). A one-way ANOVA was used to analyze the relationship between student focus/attention to content, engagement/on-task, confidence and performance across all participants. These variables, when analyzed showed significance between groups ( $p < .01$ ).



This program, though very new, is proving to be a great motivator for math learning at the third through fifth grade levels. A 2-tailed t-test was utilized to analyze the relationship between interested, body language during the learning segment, and interest of the students in grades 3-5. With equal variance assumed data showed significance ( $p < .01$ ). Another study of 1400 students was completed with Brick math in 2018 which yielded pre to post test scores gains between 4 and 6 points. Literacy is also an important skill in STEM. Build to Express utilizes a hands-on approach to build vocabulary, extend critical thinking about content, and examine content through varying perspectives. Story Starters is a system of building stories, expanding story lines, and developing storyboards. When paired with Story Visualizer, or other story boarding software technologies, the Story Starter program allows students to make Lego mini-figures and characters come alive in a story they build, write, and video- record with voice-overs. These products allow for the integration of ELA into Science, Social Studies, Math, and other content; instead of seeing ELA as a stand-alone reading class. The University-Business Partnership allowed graduate students to test these products with children and look at engagement and motivation for learning. The inclusion of Story Tales and Build Me Emotions for preschool and kindergarten brings literacy to the forefront for younger learners as well. A study around this product is currently underway.

Using Lego Bricks to ignite a passion for Math, Science and Social issues is evident in products such as Early Simple machines, Machines and Mechanisms, WeDo 2.0 Robotics and the Extensions to these programs. These are currently in existence and are being utilized in the program partnership. Whether one is studying the industrial revolution, animal adaptations, ecosystems, or energy these programs offer a wide-variety of lesson ideas building in computer science ideology. Creative thought processes and critical thinking skills are improved through the use of such materials.

For older students, the Spike Prime, and EV3 are beneficial integrated programs for technology, programming, math, science, and ELA. Using this program students need to understand math basics, be able to create, follow instructions, develop programs, and complete pre-determined tasks; amongst other things. Middle school students who have participated with this program find it to be motivating and they often claim this to be the one reason they go to school.



Beginning the use of coding and robotics materials in pre-service training programs has proven successful. It adds a sense of what true blended learning can look like in the classroom for those studying to be teachers. Candidates (graduate) at High Point University participate in a full semester of robotics training and then take activities out into schools when they become teachers. Teachers and students in participating schools benefit from the experiences of the graduate candidates, and then the schools begin to get their own teachers trained and involved in the use of the STEM strategies of the Lego system. Research (Sloan, 2017) points to the need for coding as early as Kindergarten because it relates to spatial awareness, sequential understanding, and in-depth thinking.

Francis' (2015) investigated the relationship between computational thinking, spatial awareness and language benefits. The findings were in line with the goals of robotics and coding, that students begin to learn through problem-solving actions and not from them. If pre-service candidates and graduate teacher candidates come out of universities with this understanding and knowledge they will be able to move the next generation of thinkers further. This knowledge allows them to implement a more creative set of skills into the classrooms in the schools where they pursue employment.

The integration of Pre-Kindergarten products from LEGO® Education is the next step in preparing teachers to develop even younger learners into lovers of math and literacy. A study at High Point University is currently underway to investigate how the products support social and emotional growth, math, literacy, and Engineering concepts for those in Pre-K and grade 1. Coding Express, Build Me Emotions, math Train and Tubes are currently being tested with local schools.

### **Branching Out**

In 2016, another business partnership was formed with Daimler Trucking Company. This partnership was merged with the LEGO® Education partnership to provide a middle school robotics competition program using LEGO® Mindstorms® EV3 products. In its first year 32 students from 4 Title I schools participated with their teachers. It is the intent for these schools to gain the confidence to participate in First LEGO® League in the future. The university is committed to finding and working with business partners to expand the programming outreach and informal educational opportunities for students in the area.

### **Conclusions**

This data shows the significance of partnerships, both for research and implementation of informal educational experiences for teachers and students. It also points to the need for a greater emphasis on working together for the future of learners.

Teachers need training to make these tools come alive in the right way for students. The content piece must be relevant, integrated, and seen as useful to all concerned. The investment in creative and critical thinking must be expanded if we are to lead students to the true skills needed in the global world. As a nation, we cannot continue to teach kids to read through recitation, spell through continual memorization, do math through procedural algorithms, read about and never experiment with science concepts, or read history without exploring how it might affect the future. A passion for learning comes from the degree to which one feels attached to the content he or she is studying. Research on the brain and learning points to the fact that people must be emotionally attached to content in order to want to learn about it. If students do not want to learn about it, then they check out (Blodget, 2013). If this happens it will not matter the quality of the teacher, the number of degrees of the teacher, nor the number of times you reteach and assess. The key is in the motivation and emotional connection to the content. It is not realistic to teach math in isolation and expect students to see how to use it in an integrated world. Rather, we should teach students how to use math to get to another topic that interests them, such as traveling, budgeting for something, saving money, purchasing things at a discount, distribution of goods and services and so forth. Students should learn how to discern good research from poorly designed and reported research, read about and develop perspectives about issues in the world, and work together to solve problems that plague the world around them. Integrated STEM education provides opportunities for students to practice all of the skills needed in order to compete for jobs in a global community. It is a different mindset for students, teachers, and educational leaders in terms of teacher training and professional development. For many it is a venture into the unknown and as professional educators it is necessary to make the journey. The forming of business-university partnerships is key in the global world to engaging students in STEM career topics; and providing leverage for schools and businesses to work together to help tomorrow's citizens close the creativity gap.

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