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Getting STEM Right from the Start: Using the Project Approach in Early Childhood Settings

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This paper reports on a qualitative study of a year-long in-service professional development programme for Early Childhood teachers which used the project approach and integrated Science, Technology, Engineering and Mathematics (STEM) teaching. The views of nine teachers from five government and government-assisted Early Childhood centres in North Trinidad were analysed to answer the question: What are the benefits to teaching and learning of a STEM professional development programme which used the project approach as a teaching strategy? Gusky's (2000) Model of Staff Development and Teacher Change provided the theoretical framework. Findings are reported under three themes: Teacher knowledge and skills development, Benefits to students and Resulting changes in teacher beliefs and attitudes. A novel modification to Gusky's model resulted from teachers' reflective practice. This modification is represented as a recursive cycle of teacher motivating students and students motivating teacher leading to transformation in teacher beliefs and attitudes. Recommendations for improved Early Childhood teacher professional development programmes are provided.

Keywords: *STEM, early childhood education, the project approach, teacher professional development*

Introduction

Today there is growing recognition of the benefits of high quality early education to children's development and learning. There is also the understanding that teachers play a critical role in the success of any Early Childhood (EC) education initiative. The knowledge, skills and understanding which teachers possess influence how effective they are in supporting young children's development and learning. Government in its attempt to make the EC sector a "relevant and quality system capable of responding to the demands of the 21st century" has produced Early Childhood Care and Education (ECCE) curriculum and standards of practice to assist teachers in providing high quality services for children and their families.

In spite of these supports national reports have identified gaps in EC teacher effectiveness in curriculum delivery. One report stated that early years practitioners lacked appropriate qualifications and competencies (OAS Hemispheric ECCE Team, 2004). Similarly a more recent report on the transition of children from ECCE to Primary Education, recommended that professional development opportunities be provided to all teachers (ECCE and Primary) on a

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regular basis in relation to the curriculum and methodology in the early years (Franklyn, 2010). Additionally the report recommended that the ECCE Division develop project-based learning activities to facilitate the acquisition of scientific and technological concepts. The goal is to foster, "the development of inquiry processes and build awareness of the principles of science and technology at an early age" (p. 32).

The recommendations of these reports suggest a need for teacher professional development focusing on EC Curriculum and pedagogy. They also suggest that teachers need to develop competencies in project-based learning and curriculum delivery to facilitate inquiry skills and science and technology principles. Including the project approach in professional development seemed like a logical response since it is a pedagogical strategy which involves children conducting an in-depth investigation of a topic that is meaningful to them (Katz & Chard, 2000). Additionally, using STEM as an approach to assist early childhood educators to focus and refine children's natural curiosity for learning seemed well suited to the professional development innovation. STEM teaching allows for integrating knowledge and understanding connections across the curriculum with a focus on the STEM disciplines.

This study is therefore timely and important in that it reports on a small scale qualitative investigation of a STEM project conducted by researchers from the University of the West Indies, St. Augustine. The five participating early childhood centres served children from disadvantaged circumstances thereby providing an opportunity to include a diverse student population. Using data from focus group interviews with nine teacher participants, as well as teachers' online diary entries and parent responses to questionnaires about children's learning, the effectiveness of the in-service programme was analysed to determine benefits to teaching and learning.

The following are definitions of key terms used in this paper.

STEM Education refers to the integrated teaching of Science, Technology, Engineering and Mathematics which are viewed as critical for successful 21st Century learning. STEM education was included as part of the intellectual stimulation on the curriculum alongside developing children's physical, social/emotional and aesthetic learning. It has the potential to significantly improve student interest and achievement, particularly in Mathematics and Science.

Early Childhood Care and Education refers to the provision of experiences in group settings designed to facilitate development and learning in children birth to eight years old. This study addressed children in pre- primary schools ages 3-5years old.

The Project Approach is a pedagogical method which allows for in-depth investigation of a topic of interest to children. It is classroom research designed to find answers to questions about a topic posed by young students and/or their teacher. Children are intellectually stimulated and gain a better understanding as they learn by doing, discussing in groups and revisiting ideas. Project work formed part of the curriculum which included planned units of work, thematic teaching and direct instruction.

Professional development as used in this paper refers to the in-service early childhood teacher training programme designed to improve teaching practices in STEM Education and project work ultimately leading to successful learning outcomes for students.

Background

This study is set within the context of growing recognition of the benefits of ECCE to human capital development. It also acknowledges STEM Education and project-based learning as 21st century curriculum approaches for improving learning outcomes for children particularly the most disadvantaged. The Caribbean Plan of Action for Early Childhood Care, Education and Development followed by the Regional Early Childhood Action Plan 2002-2015, set the stage for regional planning in Early Childhood Development (ECD). Further, recognition of the variety of Early Childhood Services in the region led to the establishment of a Policy Forum (Caribbean Policy Forum on Early Childhood Development, 2006). The aim was to sensitize policy makers to the importance of investment in ECD. The outcome of these consultations is a shared philosophy of learning. This philosophy informs policy guidelines, EC standards of practice and curriculum expectations within the region. Regional governments have therefore committed resources to transforming the EC sector from using traditional teacher-directed practices to more learner-centred teaching approaches.

In Trinidad and Tobago the government is working towards transforming EC Education away from traditional teaching which presented learning as “knowledge to be acquired or facts to be stored” (Ministry of Education, 2005b, p. 2). Preferred is teaching focused on engaging children in meaningful activities for developing the whole child. Towards making the EC sector a “relevant and quality system capable of responding to the demands of the 21st century” the government has introduced the National Early Childhood Care and Education Curriculum Guide for use by teachers (Ministry of Education, 2005a, p. 5). This document along with Standards for Regulating ECCE Services in Trinidad and Tobago (Ministry of Education, 2005b) as well as standardised forms for recording activities at EC centres, are some of the measures introduced to provide equitable, high-quality EC services starting with our youngest citizens. The EC curriculum focuses on five learning and development goals or strands. These strands represent desired learning outcomes for children in the areas of wellness, effective communication, citizenship, intellectual empowerment, and aesthetic expression.

The goal is to achieve high quality, universal EC education by 2015 through developing a strong foundation for continuous improvement starting at the early childhood level (Ministry of Education, 2005a). The EC education system envisioned is one which provides high-quality learning, caters to the diversity of learning needs, supports effective communication and encourages parent/family partnerships with schools. The focus is to meaningfully transmit content knowledge while equipping students with skills, attitudes and dispositions for learning.

The Harmonized Policy Framework for Teacher Education in the Caribbean acknowledges that the role and function of the teacher has changed, however the teacher’s role remains critical to achieving successful school outcomes. As a consequence, education reform must focus on teacher education to achieve the desired quality of education for students (Ministry of Education, 2005c.). Emphasis should be placed on Science and Technology goals. This study therefore reports on a teacher professional development programme which was aligned to those recommendations.

The programme aimed to support teachers’ understanding of how to use the project approach for curriculum development, while incorporating new knowledge and pedagogy for teaching STEM in their classrooms. Helm and Katz (2011) noted that there is increasing interest in project work which is now, “included in recommendations for educational reform” (Helm & Katz, 2011, p. 1). The project approach therefore facilitated the teaching of 21st century skills such as critical and creative thinking as well as problem solving and effective communication, and included the use of informational technology.

Additionally, since core understandings such as facilitating 21st century learning outcomes are also at the heart of STEM education, integrating learning through STEM while incorporating project work logically followed. The STEM Smart Brief provided further support for the programme design when it stated that educator development is one critical area that may be negatively affecting STEM learning in young children (Anonymous, 2013). The professional development programme thus fulfilled an important goal in teacher education by facilitating effective learning strategies for teachers in STEM education and developing confidence and competence to teach STEM disciplines using the project approach.

A study by Williams, Walter, Henderson, and Beach (2015), demonstrated that STEM integration complemented the project approach in laboratory, hybrid and online environments. This finding was in keeping with Mendoza and Katz (2013) who described the value of using the project approach in teaching Science and Nature Education. Further, the trend of uniting the project approach and STEM integration in teacher professional development in the Mathematics and Science disciplines proved advantageous when the strategies were merged.

As a consequence, the programme investigated used STEM integration and the project approach. It lasted one year and involved nine preschool teachers from three government and two government-assisted EC centres in Trinidad. It is noteworthy that although the project approach is already an established teaching strategy in all government-affiliated early childhood centres in Trinidad and Tobago, teachers in the study welcomed the opportunity to develop their skills and gain confidence in doing project work.

Purpose of Study

This qualitative study was conducted to provide some insight into the views of nine early childhood teachers from government and government-assisted early childhood centres, about the benefits derived from integrating STEM disciplines in teaching 3-5 year old children using the project approach. The study presents the views of participants and stakeholders about the benefits of a professional development programme which used STEM and the project approach as a strategy for teaching young students. Projects selected were integrated and in sync with the school curriculum, for example, “the Dump Truck Project” fitted in with the theme of “Transportation”.

Teacher training for project work started with a focus group meeting with two mentors to sensitise the schools and obtain “buy in” for the project. Another pre-activity was to identify resources and facilities available at the schools. Upgrades needed included providing internet access at all centres. A one-week training course was conducted at the University to teach critical thinking skills and questioning techniques to teachers for imparting to their students. Teachers also learnt about STEM teaching and discussed ideas for conducting STEM projects. They got internet addresses, and learnt how to do blogs and wikis and to post reflective messages online. In the routine planning of their units of work for the term, project work with a focus on STEM was included. Later, a second week of training further explained the project approach. The training matrix is represented in Table 1.

Table 1

The Matrix of Activities for the STEM project

Date	**Activities**
January – February	Pre-activity- gaining entry
March (1 week)	Teacher training at the University in critical thinking skills and questioning techniques and STEM teaching and projects. Also ICT training.
April- June	Period of classroom practicum, mentoring site visits were conducted to observe teaching /planning and make recommendations; ICT use was encouraged for blogging and curriculum development.
August (1 week)	Teacher training at the University on the project approach, unit planning and integrated planning and developing STEM projects.
September - December	Period of classroom practicum, mentoring, ICT use and developing products for the child conference
January	Child Conference, Student display of presentations

Teachers implemented what they learnt in two classroom practicum phases during April to June and September to December. Research data were collected throughout the year-long programme.

Recommendations for the future use of the teacher education model as well as improvements to support structures for future implementation are also included. Although the study was small scale and generalizations cannot be made nevertheless the researchers suggest possible reforms to the EC sector which may better facilitate using the project approach as a teaching strategy for integrating STEM teaching in EC centres.

Methodology

A qualitative case study of the year-long professional development programme was conducted. The professional development model involved:

- Two weeks of teacher training programmes divided into two teacher training modules
- Two terms of mentoring teachers' practice in STEM teaching and using the project approach to develop projects in classrooms,
- A child conference where children showcased the products made from their projects to their peers, family and community members.

Five early childhood centres - three government and two government-assisted centres from north Trinidad, which participated in the professional development programme were the sites studied in this investigation. Government-affiliated sites were selected instead of private centres because those sites served some children from disadvantaged circumstances whom the researchers wanted to benefit from the STEM programme. Additionally teachers at those centres (unlike the private centres) were required to use the project approach as part of their curriculum. Some teachers however admitted that they needed professional assistance to better understand how to facilitate projects with young children.

A further basis for selecting government-affiliated sites as opposed to private sites was that those centres were more likely than private centres to have structures in place to support the STEM Projects. Those structures included: more highly trained teachers; smaller class sizes and higher adult-to-child ratios; age-appropriate curricula and stimulating materials in a safe physical setting. These structures were favourable for the success of the project as they represented some of the key elements identified by a synthesis of international research on teacher education programmes for improving learning and developmental outcomes for young children (Center on the Developing Child, Harvard University, 2007).

Additionally, the centres represented three of the eight educational districts namely St George East, Port-of Spain and Environs and Caroni Educational District. Students from those centres reflected the diverse mix of students typically attending government EC centres in Trinidad on the basis of socio economic status, gender and from urban and rural settings. The centres were also selected for their proximity to the University, as ease-of-access for the two facilitators assigned to site visits during the mentoring phase of the project was a consideration.

Eight of the nine participating teachers were trained to the certificate in ECCE level with five having completed or nearing completion of the Bachelor of Education degree in ECCE. One teacher from a government-assisted centre had received up to in-service EC teacher training.

The professional development programme involved attending face-to-face sessions where teachers were introduced to teaching strategies for using the project approach with children. They also engaged in mini projects such as constructing bridges, to hone the skills of problem solving as well as critical and creative thinking which they learnt in classroom sessions. They were then required to teach those skills to their children. Online support for the use of Information and Communications Technologies (ICTs) was incorporated throughout as teachers were mentored to use computers, cell phones, cameras, and computer tablets in developing and delivering teaching units.

Although there were nine teachers, seven projects resulted since teachers were paired- off to work on the “Car and Traffic Lights” project at one centre and the “Our Community” project at another centre. The other five projects were: The Mosquito Project, The Bees, The Dump Truck, The Compost Project and the Recycling Project. Even though project topics differed, they all facilitated what was normally done in integrated curriculum planning using a thematic approach. Teachers planned units of work to ensure learning experiences covered the five curriculum strands. What was different was greater emphasis was placed on Mathematics and Science teaching and the use of ICTs and engineering principles, wherever possible.

Students researched project ideas by listening to stories, viewing videos and discussing ideas before drawing and making prototypes of their planned class projects. They worked with their peers and more knowledgeable adults, which included teachers, parents and community members, to develop a final product for the child conference. Students also rehearsed explaining their products and the process involved in developing products. Additionally, they practiced answering possible questions from conference visitors.

Data were collected from two focus group interviews with participants at the end of the project. The focus group interviews were audio taped, transcribed and checked for accuracy. Following guidelines by Creswell (2004) for qualitative data analysis the transcribed interviews were coded and analysed to identify the benefits of the professional development programme. Additionally teachers’ reflective online diary entries posted throughout the programme were analysed. Triangulation was achieved by analysing parents’ and conference visitors’ responses to a questionnaire about the project.

Analytical Framework

To determine the success of the professional development programme this study used Gusky's (2000) Model of Staff Development and Teacher Change (see Figure 1) as its analytical framework. The model proposes that staff development which involves changes in classroom practice is likely to result in real change in teacher beliefs and attitudes only after teachers witness changes in student learning outcomes. Learning outcomes incorporate the methods teachers use to judge the effectiveness of their teaching. They include cognitive and affective variables such as motivation for learning and students' attitudes toward school. This model therefore allowed for an analysis of teachers' responses about how student learning benefitted from the professional development programme.

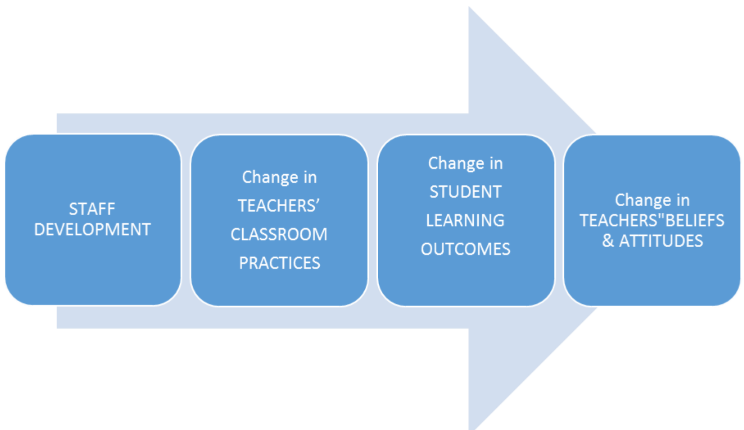

Figure 1: Gusky's (2000) model of staff development and teacher change

This study was designed to answer the question: What are the benefits to teaching and learning of a STEM professional development programme which used the project approach as a teaching strategy?

Findings

The data suggested that the programme provided benefits to both teachers and students. Challenges related to planning Science and Mathematics lessons as well as using the project approach and ICTs were overcome through support provided by mentors.

In developing the themes each data source was first coded using open-coding and then axial-coding to develop themes. Three themes emerged from the data after line-by-line coding using the constant comparative method (Corbin & Strauss, 2008). Eleven sub-themes were identified from the themes. Table 2 shows the themes and sub-themes.

Table 2

Themes and sub themes

Themes	**Sub-Themes**
1. Teacher Knowledge and Skills Development	• Understanding STEM skills • Confidence in Teaching Science and Mathematics • Understanding STEM Teaching through Reflective Practice • Skills in Research and Technology use • Challenges Encountered
2. Benefits to Students	• Highly Motivated Students • Parent Involvement in Learning • Enhanced Communication Skills
3. Resulting Changes in Teacher Beliefs and Attitudes	• Teacher motivation to succeed • Building Teamwork and a Learning Community • Discovering Student Interest and Abilities

The following is an explanation and analysis of the themes. All names are pseudonyms.

1. Teacher Knowledge and Skills Development

Understanding STEM skills. A strong theme which emerged was that the programme developed teachers' skills for facilitating STEM integration using the project approach in a number of ways. First of all, the professional development programme equipped teachers with skills for teaching higher-order thinking skills. One teacher's comments about her skills development were: *"The help that I got in the training sessions was ... it highlighted different things that we could have done with the children, and different skills that we could have enhanced, like the critical thinking skills, and the creative thinking skills and all the different thinking skills that we could have enhanced with the children."*

The reference was to the one-week training session in which teams of teachers engaged in classroom exercises which included projects for example to design and construct strong paper bridges. Teachers learnt about questioning techniques for eliciting critical thinking skills. They also participated in activities to enhance their creative thinking, critical thinking and problem solving skills in preparation for teaching the skills to their students. The idea expressed by the teacher was that skills learnt during the professional development exercise were useful for teaching intellectual skills to her students.

Another teacher, Anna, explained that she gained a better understanding of how to develop children's skills using the project approach. She remarked, *"Yes, we do projects to a point, but I don't think in our classroom that we really endorsed those types of skills as how it supposed to be endorsed. The STEM [training sessions] really help me to understand the whole idea."*

This new understanding and change in practice that resulted can be related to the change in teachers' classroom practice that is expected to result from professional development (Gusky, 2000). Parents and teachers attending the child conference also noted the new skills demonstrated by the students. They were impressed by the "young age" of the students and how "brave and knowledgeable" children were when they presented their projects on stage.

Confidence in teaching Science and Mathematics. Teachers initially expressed some fear and uncertainty about not doing the "right thing" when they attempted to practice new approaches learnt for integrating Mathematics and Science concepts in their teaching. They lacked confidence to teach Mathematics and Science beyond topics traditionally taught. However with support from mentors, teachers developed confidence to teach new concepts and skills and their competence improved. Miss Amanda said, *"While doing the STEM project, I was kinda worried and concerned that, I wasn't meeting the STEM part of it, but when the mentor came, and I showed her what I had, she kinda give me assurance that, okay, I'm going on the right track: that I just need to tweak it here and there, you know."*

Miss Amanda's class worked on a Dump Truck Project. As children asked questions, she listened, observed and extended children's learning about Mathematics and Science concepts through questioning and further inquiry activities. Her teaching confidence improved when the mentor assured her that what she was doing with the children followed the professional development guidelines given. Further, the project activities and experiences grew from the children's experiences and interest. She stated that children learnt about the windscreen and hydraulic system on the dump truck. In addition to counting and number sequencing they did geometry as they explored two - and three-dimensional shapes on the cabin. This type of incidental learning seems to reflect teacher facilitation of intuitive mathematical knowledge processes through informal everyday experiences (Copley, 2010).

Throughout, integrating Science and Mathematics concept teaching across the curriculum was fundamental to lesson planning. Four-year old Kyle was keenly interested in the hydraulic pistons that raised the back of the truck. To satisfy his curiosity and integrate STEM learning, the class of 15 children was taken on a guided tour of a real dump truck owned by a community member. The experience encouraged curiosity, questioning and taught them new concepts and increased their vocabulary. An example of this was when four- year- old Mike asked, *"Why can I see you through the windscreen glass?"* In explaining that concept, words like transparent and opaque were studied.

The teacher provided names for the parts of the truck and their uses. She also had them draw and make prototypes of miniature dump trucks from shoe boxes and a class dump truck from a huge refrigerator box which later became the highest demanded outdoor play area for the children. When they worked with their teacher and a community member to construct a model dump truck, the children engaged in problem solving as they suggested and innovated to make a hydraulic system. The experiences encouraged investigation and experimentation with mathematical concepts deemed necessary (Copley, 2010). It also provided opportunities to integrate hands-on and minds-on experiences necessary for supporting reflection, theory making, and understanding in Science (Minner, Levy, & Century 2010).

Understanding STEM teaching through reflective practice. Teachers stated that the professional development programme taught them about integrated teaching. Prior understandings of STEM subjects were that they were separate disciplines. However new learning helped teachers to understand new possibilities for teaching in an integrated way. One teacher stated, "*My concept of Science, Technology and Engineering and Maths, you know, these four areas were like totally different areas, and wasn't interrelated. But, you know, as you go through the process, this STEM project, I understand that, each phase of the process, had different aspects of the STEM areas coming out and it wasn't something that was different and separated, it was something that is interrelated."* Further, the notion that this learning influenced teachers' attitudes and dispositions was also evident when Ms. Riley stated, "*In life now, I'm seeing and viewing that in life these things happen every day, and…areas (Science and Mathematics concepts) come out in different aspects. But you know, I was not really aware of it, but you know now I've taken a deeper look and a reflective look at my practice. Now, I say that, you know, things are not separated, but interrelated, and it have certain connections within everything that you do."*

The teacher's explanation of her new learning seemed consistent with reflective practice where self-reflection leads to higher forms of understanding. She explained the process of stepping back and taking a "deeper look" at her understanding about integrated teaching and learning. Her experiences in doing the project had brought about new knowledge about the interrelatedness of integrated learning. Brockbank and McGill (2007) described this type of learning when they explained that reflective learning is an intentional social process based on context and experience. The benefit of reflective learning is that the learners experienced transformation which led to improvement for the individual and the environment.

Skills in research and technology use. Teachers also developed research skills and increased their knowledge base as they had to, *"bring new information to the children"*, one teacher remarked. Similarly, to achieve technology goals they had to become more proficient in the use of computers and other ICT devices often becoming innovative by using available resources in new ways. They used their cell phones for peer messaging and recording videos of student interactions for peer critiquing.

ICT use was facilitated by an ICT specialist who also provided ICT tools such as tablets and cameras and introduced teachers to new ways of developing the curriculum using whatever ICT tools were available at their schools. This support ranged from providing some teachers with email addresses and creating blogs and wikis, to sharing reflections and exchanging ideas on projects online. One teacher said that through the ICT support that they learnt about, *"all the nice, creative, technological tools"* that could be used.

Challenges encountered. Due to limited Science and Mathematics knowledge and understanding of the project approach, teachers experienced difficulties during planning and implementation of the projects. Though mentoring helped, the frustration experienced with planning sometimes threatened the success of the programme. One teacher stated about planning: *"Sometimes I did it over three times, in order to get the children involved. And then I had to change some of it, the vocabulary had to change, so I had to go back and do research in order to bring it to children, pre-schoolers, it was a bit difficult. But in the end, how we treated with it, they really, really enjoyed it."*

Another challenge was that of the timing. The programme commenced at the start of the first term when children are normally oriented into their new classes. Consequently there were some difficulties with managing children's behaviours and trying to meet the goals of project deadlines. One teacher stated that *"Being the first academic term, we had to focus a lot on* *discipline and the different personalities of the children."* Teachers suggested that the programme should have started in the middle of the first term or in the second term of the school year when the children might have been more settled.

A third challenge for three teachers was the use of computer technology. Ms. Chadee said, "*One of the challenges that I had was in terms of technology. Yes I know how to go on the computer, turn it on, type and stuff like that, but…when we did the training process, I don't think I got enough practice, so I was not able to communicate with my mentor to, you know, to get the information to her, and to receive the information from her. But I'm thankful that she came in, because I think if she didn't come to visit us, I would have still been fidgeting around."* Though each challenge was overcome, they provided some difficulties for teachers.

2. Benefits to Students

The following sub-themes emerged to explain how the project benefitted students by motivating them to learn and fostering their interest. Student interest further motivated teachers, parents and community members.

Highly motivated students. At all centres students became extremely interested in doing STEM projects and learning. At one centre where students were learning about diseases spread by mosquitoes and how to prevent mosquito breeding grounds, Ms. Prudent said, "*Mikaila would say every week, "Aunty, what are we going to do in STEM today?" Now, when you look at that little face, you can't just say, "Okay, I not doing anything." You know, she was one of the motivators for me….that's what helped me along."*

Teachers benefitted most from the high level of student interest generated when they were motivated to persevere in spite of difficulties experienced due to personal or work-related factors. One teacher reflected that the students' level of interest motivated her as project work took the children's *"enthusiasm to another level."* Miss Tam said, "*And then, the children's motivation level, it was like…"Oh my gosh!" "Ms. Tam, what we going and do today?" And, "We going and make the machine today?" And you know, they want to do it, and that level of interest really pushed me forward to finish the project."*

Miss Tam and her class developed a machine to sort waste produced by the class for recycling. In the process children learnt about classification, developed numeracy skills and produced engineering blueprints of the waste sorting machine. One child's idea of what the machine should look like was used as the prototype for developing the machine. Additionally the project resulted in a reduction in waste generation by the highly motivated students. Ms. Tam said this was highlighted after the Christmas party when the janitor remarked, "*But we hardly have any garbage bags to put out! Everything [seems to be] going for the recycle project*." So it had impacted the centre generally.

Parent involvement in learning. Students' high interest level inspired by the STEM projects and new learning in Mathematics and Science achieved affective learning outcomes. Parents attested to this. One parent at the centre where the recycling and compost projects were done said, "My child is looking at every cartoon (box) and she is wondering and saying, *"Mummy, don't throw this away! This could be recycled! And this (food item) could go for compost."*

As children learnt about recycling and composting at school they took the new knowledge home. Parents said that they too were learning about things like the recycling symbol and becoming more aware of the process involved in composting for reducing waste and enriching soil for plants. One parent assisted the teacher and children in developing a tumbler for mixing the organic waste produced with soil to produce compost. As parents became more interested and involved they assisted with developing a small kitchen garden where the children grew lettuce and added their compost to enrich the soil. Similar examples of parent involvement becoming more than attending parent/teacher meetings but also including parent-initiated discussions and suggestions for curriculum implementation were reported from each study site. Also at the child conference, parents' eagerness to participate was captured by one mother's comment. She said that, "*Based on the high quality of the projects displayed, parents will be highly motivated to partner with the school system."*

Enhanced communication skills. Children also developed a new repertoire of skills for thinking and expressing their ideas. The following vignette illustrates one instance of a child's developing engineering design skills. Ms. Tam explained with excitement, "*There was one instance when it wasn't a planned activity. A little girl, she came up to me and she said… "I want the whiteboard." I said, "What [do] you want the whiteboard for?" She say, "I want the whiteboard and the marker… you know… the machine that we have to build, I want to draw it out for you." And I said, "Hold on, let me get…my (computer) tablet." I put it on to videotape her and I said, "Alright, let us draw." And she started to draw it, and I didn't even know she had that ability. She actually drew a model that you could…actually see the whole…the different sections and the different areas, and she actually drew out the recyclables and where it was supposed to be in the big bin, and then she say, she said, "You know what, you have - it have a door here, and you have to press the button-", and I said, "But what happen when the button press?" She said, "You know, the door does open, and the things does move, on something." I said, "But what is that called?" She didn't know the name for it so I told her it was a conveyor belt.*

This was an example of a child demonstrating new skills in engineering design. She used information from a video on waste sorting at a dump site to draw a design for the class model of a machine for sorting waste. The child's interest and ability was discovered through the STEM project. Furthermore the teacher admitted that she had underestimated the child's ability.

Children's language skills were also enhanced as their vocabulary increased. One teacher stated that by encouraging students to verbalize their thoughts, children became more expressive. She said, *"It took them a while to be able to express what they wanted to say "with their vocabulary and stuff."* Another teacher stated, "*The children actually learnt the vocabulary. One day when we had food time, a child said, "Miss, this apple - this apple is decaying." When he bit into the apple, it was really rotten, but he used the word, "decay", and we were so (amazed and elated) … and I ran up to him and I hugged him.*

The teacher expressed her pride and amazement when she actually heard her pupil using new vocabulary. Hart and Risley's (2003) estimation that children from professional families are exposed to about 42 million words by age 4 as compared to 13 million for the child from a poor family can put the child's vocabulary development in context. Further Nagy and Stahl (2006) reported that the size of children's vocabulary knowledge is strongly related to their understanding of what they read. This was therefore an important outcome of the STEM programme particularly for children with limited vocabulary exposure. An important learning outcome for early childhood literacy development in the Caribbean identified by the Caricom Secretariat (2010) was thus being facilitated.

3. Resulting Changes in Teacher Beliefs and Attitudes

Teacher motivation to succeed. Teachers also expressed the view that even though the STEM project was challenging they nevertheless were committed to completing the programme. This is supported by the fact that there was no attrition of teachers as 100% completed the seven projects started. Also when there was difficulty understanding how to teach STEM concepts to young children, teachers meticulously researched and planned until they got it right. One teacher said, "*In order to bring…the whole project to life, I had to do a lot of research. And in my research, there were new terms not the terms that I started off using… I went back and I investigated and I realized that I could use- "millipede" instead of the local name "congoree"- The whole aspect of the Science first.*

Discovering student interest and abilities. Through the STEM projects teachers gained new knowledge about the interests and abilities of their students. Miss Tam explained that she actually saw: "*The different skills of the children, and interest areas which wasn't highlighted [previously]…through the… project approach. You see the different areas, like the skills, that the STEM endorse, like the Science area, you'll see who are the children who…more into Science, who are the children more into Technology, who are the children more into Engineering, who are the children more into the Math concepts and all these things. So you saw the different interest areas with the children."*

Even beyond this understanding of students' individual interests was that teachers discovered that they had previously underestimated what students knew and were capable of learning. Ms. Brown said, *"I was amazed at the children's previous knowledge, in terms of, they knew the engine, they knew and could have recognized the seatbelt, the number plate; they were actually able to name some of the parts of the car."* That discovery occurred at the centre that did the Car Project. The students worked with their teacher and also in conjunction with personnel from a community science centre to develop a model of a car and a traffic light. This discovery has implications for teaching, as teachers are better able to plan for children's learning when they have an accurate understanding of children's previous knowledge and potential for learning.

Another discovery was that children's high motivation level, further motivated teachers. Teachers explained that the students were bombarding them to do project work every day. That level of student interest further motivated teachers to complete the project.

Building teamwork and a learning community. An affective outcome of the project was that teamwork was built in the process. Miss Jamie remarked that they became a very strong team by working together. She added that, "*because each one of us has a different skill, when we combined these skills, we became a perfect team.*" Another affective outcome was that through interacting with teachers from other centres a learning community was started. One teacher stated, "*I met a lot of new teachers, and some of them are within the environment (my community) that I could go to now, so I think we actually building a learning community. That is one of the beneficial aspects …of the STEM project*."

Summary

Though Gusky's (2000) Model suggests a linear progression from professional development to changes in teachers' beliefs and practices this study found a recursive cycle being set in motion along the way. Represented in Figure 2, the change in teachers' classroom practices motivated students. This led to positive change in student learning which in turn motivated teachers. Ultimately change in teachers' beliefs and attitudes resulted. The recursive cycle of motivation discovered is superimposed on Gusky's (2000) Model of change in Figure 2.

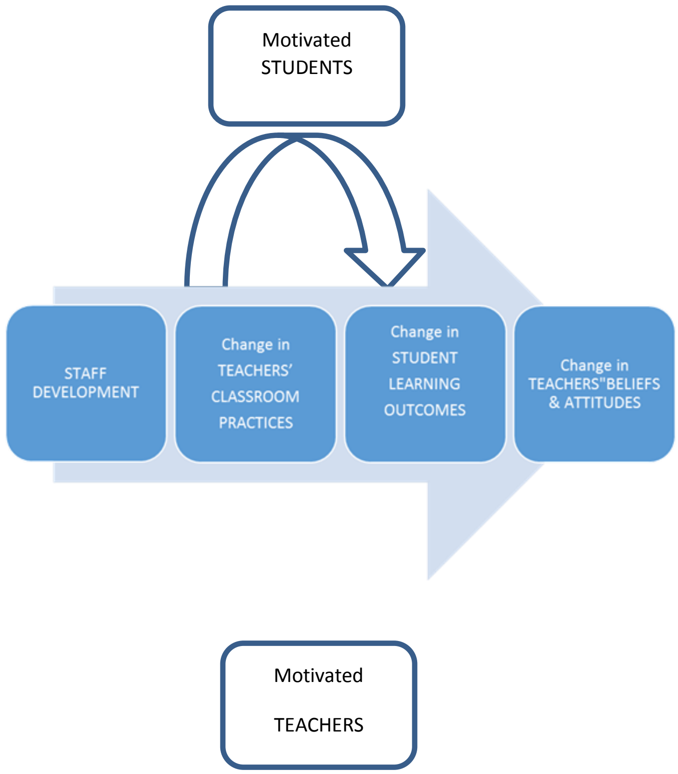

Figure 2. A modified version of Gusky's model of staff development and teacher change

Ultimately teachers' views of the benefits to student learning can be summed up using the words of one teacher who exclaimed in amazement as she reflected, "*I was watching the children different with these skills and it was like, oh my God! Oh my God, [look] what STEM could do!*"

Conclusion and Recommendations

The driving research question for this investigation was: What are the benefits to teaching and learning of a STEM professional development programme which used the project approach as a teaching strategy? Using Gusky's Model (2000) of Staff Development and Teacher Change for analysis, improvements to teachers' classroom practices were observed. This positively influenced student learning and assisted in changing teacher beliefs and attitudes towards teaching STEM.

The study revealed that the knowledge and skills teachers gained boosted their confidence in STEM and in teaching Science and Mathematics, two subjects which EC teachers often experience difficulty teaching. The STEM Smart Brief (Anonymous, 2013) highlighted that the focus at the ECCE level has traditionally been on developing children's language and literacy skills. Further teachers often lack confidence and competence because teacher training did not adequately prepare them to teach STEM disciplines. The programme however facilitated reflection on new learning which resulted in greater understanding for STEM teaching. The programme also encouraged teamwork at each centre and across centres as learning communities developed. Teachers also learnt about the interests and abilities of their students. Additionally, teachers gained skills in research and even though there were some challenges, gains were made in technology use.

Students benefitted as they were highly motivated to learn. This enthusiasm further motivated teachers who became further motivated to meet student needs. In the process, teachers made new and unexpected discoveries about students' interests and abilities. Students' thinking and communication skills also developed.

The professional development programme was thus successful in facilitating teachers' acquisition of knowledge and skills for motivating student learning through STEM. Teachers can better understand integrated learning by planning and delivering STEM units. They however need mentors to validate their teaching. Since ICT use was a challenge for some teachers, more careful planning for this component would be beneficial. All students including those in disadvantaged circumstances, who are often excluded, can benefit from projects which facilitate problem solving, creative thinking and critical thinking skills development. Students' vocabulary and communication skills can be enhanced. Programmes such as these provide opportunities for reflective practice which leads to new understandings and transformation in teaching and ultimately student learning.

There are some limitations to this study. First of all, qualitative inquiry though well suited to providing in-depth, rich understanding of early childhood phenomenon (Hatch, 1995), does not provide findings which can be generalized. This research undertaking is therefore limited in that it investigated a small-scale programme involving five ECCE centres and nine teachers from government-assisted centres in north Trinidad. No private centres were included in the study. The study can nevertheless provide some insight for planning similar professional development programmes under similar circumstances.

The findings can also provide insights for realising national educational goals aimed at high-quality EC education, and catering to diverse learning needs, supporting effective communication and encouraging parent/family partnerships with schools. Further, the programme provided an innovative model for introducing STEM in early education. Consequently this study provides research-based findings for improving the quality of professional development programmes which focus on integrating STEM disciplines and the project approach in ECCE.

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