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The Design and Validation of an Early Childhood STEM Classroom Observational Protocol

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Abstract
Across K-12 education, there has been recent attention to the learning opportunities available to students in science, technology, engineering, and mathematics (STEM) learning. Early childhood education (ECE) has been excluded from this process. The scholarly literature contains good evidence for including science teaching and learning at the ECE level, however, little is currently known about how a STEM curriculum might best be implemented in the early years. Additionally, data collection tools specifically developed for ECE STEM are limited. In this paper, we outline the steps we have taken to design and validate a classroom observation protocol (COP) intended to capture aspects of STEM instruction in an early childhood setting and to help educators envision and adjust their own teaching practices. The detailed explanation of the development and validation of this data collection tool offers other educators and researchers a path for collecting evidence of STEM practices in their own classrooms and/or research environments.

Keywords: STEM, early childhood education, Pre-Kindergarten education, Classroom Observation Protocol, data collection tools, development and validation

Introduction

This article reports a study of ways to examine the implementation of a science, technology, engineering and mathematics curriculum in the early years. The National Research Council of the United States of America (NRC, 2011) has identified three broad goals for STEM: an increase in advanced training and careers in STEM fields; an expansion of the STEM-capable workforce; and an increase in scientific literacy among the general public. The acronym STEM is sometimes used to refer to any one of the individual disciplines, sometimes to denote the integration of all four disciplines, and sometimes to mean a combination of two or more of the disciplines (National Academy of Engineering and National Research Council, 2014). Our perspective, shared by other early childhood specialists (c.f., Moomaw, 2013), is that an activity can be considered STEM if any two of the four disciplines are intentionally emphasized.

One of the key goals of education is to establish an environment that supports an appreciation for lifelong learning; thus, an important question to raise is just what kinds of experiences within early childhood education (ECE) can foster such a disposition in children (Katz, 2010). There are suggestions that STEM at the early childhood level, if approached correctly, could offer opportunities for teachers to engage young children in activities that capitalize on students' interests, experiences, and prior knowledge (NRC, 2011). In this article we briefly make the case for including STEM in ECE, describe a project in which we are observing the implementation and effects of a Pre-Kindergarten (Pre-K) STEM curriculum, and then explain the development of a data collection tool that facilitated our observations. (Note that Pre-Kindergarten and Pre-K are terms used across North America to describe formal education programs for children who are four years old. Elsewhere, Pre-K education may be called Junior Kindergarten). This data collection

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tool could be used to ultimately aid early childhood educators in regular assessment of teaching and learning.

Setting the Scene for STEM in Early Childhood Education

There is a large and comprehensive body of literature about what effective science instruction looks like, with a small section devoted to what effective science instruction might include in ECE (Leuchter, Saalbach, & Hardy, 2014). Suggestions within this literature are that science instruction at this level should address what children know and what they can learn, involve an inquiry approach, and provide appropriate scaffolding to foster conceptual understanding and reasoning (Furtak, Seidel, Iverson, & Briggs, 2012; Hardy, Jonen, Möller, & Stern, 2006; Leuchter et al., 2014; Trundle & Saçkes, 2012). Katz (2010) suggests that an appropriate science curriculum in the early years is one that encourages and motivates children to seek mastery of basic skills in the service of their intellectual pursuits. Rather than "delivering" education, educators are most likely to help children in their learning by "providing" experiences known to benefit young children. Additionally, Eshach and Fried (2005) argue that science is an important – and perhaps imperative – component of ECE as it builds upon students' innate interests in the natural world, can help develop positive attitudes towards the discipline, and can provide a foundation upon which further learning and understanding can be built.

Overall there appears to be compelling evidence for including science in ECE, but what about including STEM? Even though early childhood experiences influence later academic success (Human Learning Early Partnership, 2009) and it is likely that quality ECE STEM experiences will lead to future academic success, attention to STEM education still tends to be focused on the secondary and middle school levels of the K-12 range, both in the literature and in the classroom. Nevertheless, there are several recent documents addressing connections between science and STEM education that have influenced our ongoing work in this area. First, the *Position Statement of Early Childhood Education* (National Science Teachers Association, NSTA, 2014), which focuses on children from three years through preschool, describes the capacity of children to engage in the process of science and develop conceptual understanding, the important role adults play in contributing to these early experiences, the varied opportunities that such experiences can take at this level and the time required to achieve such ends. The NSTA statement focuses on children's predisposition to observe, explore, and discover the world they are surrounded by and affirms that learning science and engineering practices foster enjoyment, curiosity and lay the foundation for the progression of science learning thru their entire lives. Specifically, the position statement (NSTA, 2014) suggests that learning science and engineering practices in the early years (i) fosters children's curiosity and enjoyment in exploring the world around them, and (ii) lays the foundation for science learning in K–12 settings.

The second document we referenced was the *Next Generation Science Standards* (*NGSS*, Achieve, 2013) which is based upon the *Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (NRC, 2012). The *NGSS* influenced our work in two ways. First, it clearly identifies and describes the major ideas of K-12 science education (i.e., that science is a series of cognitive, social, and physical practices of inquiry, which involves concepts that cut across science topics - such as patterns or change - as well as core content knowledge). Secondly, it integrates understanding the ideas of science with engagement in science practices and offers a prominent place to the ideas and practices of engineering. More specifically the *NGSS* outlines three dimensions in which science and STEM education can be integrated: (i) science and engineering practices: inquiry and problem

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solving (design); (ii) cross-cutting concepts: key underlying ideas that are common to a number of topics; and (iii) core ideas: specific content and subject areas (Achieve, 2013).

Both the NSTA (2014) position statement and the *NGSS* (Achieve, 2013) clearly emphasize aspects of engineering within and alongside science instruction. When this emphasis is considered, along with the categorization of mathematics as a foundational area at all education levels including early childhood (cf., BCME, 2008, OME, 2010), all that remains is the addition of technology to develop STEM at the early childhood level. This final leap is not too large when one considers that technology in this discussion is more than information communication technology and includes any tools that are used to solve problems.

Our Objective/The Problem Space

Drawing on the literature about science in ECE, and influenced by the NRC (2012), the *NGSS* (Achieve, 2013), and the NSTA (2014), we began an observational study in a Pre-K classroom in which two early childhood educators were implementing a STEM curriculum. These two educators had invited the first author to support them in their efforts and he subsequently asked the second author to join the group and create a formal research team. Together, we are examining the processes that these early childhood educators use in designing, implementing, and refining a STEM curriculum for students in Pre-K at a small independent all-girls school in British Columbia, with plans to expand to other primary grades and additional schools. The students and their parents are also participating in the study, enabling us to explore the perspectives of a range of stakeholder groups.

The goal of our study is to investigate how STEM education might be effectively implemented in an early childhood learning environment, while highlighting benefits and challenges. The study includes an action research perspective, with the participating educators reflecting on their current STEM curriculum and acting on personally meaningful questions.
Key objectives include:

- collecting data within a Pre-K learning environments to better understand the design, delivery, and challenges of STEM education at this level;
- determining areas to target for improvements in Pre-K STEM curriculum; and
- developing suggestions for implementing STEM programming in ECE.

As is the case in all research, appropriate data collection tools are a necessary component of this study. However, although observation protocols exist for STEM teaching, such as the Electronic Quality of Inquiry Protocol (EQUIP, Marshall, Horton, & White, 2009) and for ECE classroom environments, such as the Classroom Assessment Scoring System (CLASS, Le Paro, Pianta, & Stuhlman, 2004) and there is literature available on how to go about selecting and/or using such tools (e.g., Institute of Educational Services, 2009; Le Paro et al., 2004; Marshall et al., 2009), there was nothing we could find in the literature that focused on the overlap between STEM learning and ECE learning environments. Thus, we decided to draw on literature focused on STEM with older students (e.g., Brown, 2012), early childhood education (e.g., Le Paro, Pianta, & Stuhlman, 2004), or early childhood science (e.g., Trundle & Saçkes, 2012) to design and validate a classroom observation protocol (COP) that we could use in our research project, and that would also be useful as an assessment tool for ECE teachers.

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Development of the ECE STEM COP

To provide the foundation for a Classroom Observation Protocol (COP) for STEM in ECE, and develop a tool that could provide snapshot evidence of classroom interactions within ECE STEM education, we reviewed relevant standards and position statements: the *Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (NRC, 2012), the *NGSS* (Achieve, 2013), and the *Position Statement of Early Childhood Education* (NSTA, 2014). Then, since effective practices for STEM are closely related to effective practices for education in general (e.g., NRC, 2011), we analyzed two provincial government framework documents on quality ECE programs. We selected items from British Columbia and Ontario, since these are the provinces where our respective universities are located, and they are also the provinces containing two of the three largest urban regions (i.e., Toronto and Vancouver) in the country (Statistics Canada, 2013).

The first framework we drew on was the *British Columbia Early Learning Framework* (*ELF*, British Columbia Ministry of Education, BCME, 2008). The *ELF* is a guide for early childhood educators (among others) who are providing learning experiences for children from birth to kindergarten. This document outlines early learning as young children's physical, intellectual, emotional, social, and creative capacities and emphasizes the natural curiosity that children are born with, the role that others in their lives can take in supporting learning, and the role that early learning plays in establishing a foundation for lifelong learning. The *ELF* (BCME, 2008) identifies key areas for learning such as (i) well-being and belonging (explore their own strategies for learning), (ii) exploration and creativity (explore the world using all their senses; build, create, and design; actively explore, think and reason; identify and try possible solutions to problems; develop a sense of wonder for natural environments), (iii) languages and literacies (develop the capacity to communicate; use numbers, measurement, and form), and (iv) social responsibility and diversity (understand how their actions may affect nature).

The second government framework, Ontario's *Early Learning-Kindergarten Program* (*ELK*, Ontario Ministry of Education, OME, 2010), describes a strong foundation for learning in the early years that promotes the physical, emotional, and cognitive development of all children. The document is based upon six principles: (i) early learning is foundational for lifelong learning, (ii) family and community partnerships are helpful in meeting young children's learning needs, (iii) respect for diversity, equity, and inclusion are essential, (iv) planned curriculum is necessary, (v) play capitalizes upon early learners natural inclinations towards curiosity, and (vi) knowledgeable educators are essential. More detailed than the *ELF* (BCME, 2008), the *ELK* (OME, 2010) is broken into learning areas and program expectations around language, mathematics, science and technology, inquiry and forms of play.

Comparing these two ECE frameworks, we identified five aspects of effective early learning environments that were common to both, that would be relevant for STEM education, and that would be integrated into the COP. These aspects and their description in the two documents are shown in Table 1.

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Table 1 Aspects of Early Childhood Education that are Relevant for STEM Education

Aspect	*ELF* (BCME, 2008)	*ELK* (OME, 2010)
Questioning	• ask questions, explore, and make discoveries	• raise questions about objects and events around them
Exploring and Observing	• actively explore, think and reason • explore the world using all of their senses	• explore objects and events and observe the results of explorations • make observations, using all of their senses, and generate questions
Developing Skills and Processes	• build, create, and design using different materials and techniques • use numbers, measurement, and form • identify and try possible solutions to problems	• gather, compare, sort, classify, order, interpret, describe observable characteristics and properties, • notice patterns, and draw conclusions, using a variety of simple tools and materials
Communicating	• develop diverse language abilities and communicates with others	• work individually and with others, and share and discuss ideas through talking, listening, writing
Playing	• play is vital to children's healthy development and learning	• content is learned through play, investigation, and intentional teaching

These five *aspects* formed the foundation for our ECE STEM COP. The *NGSS* (Achieve, 2013), the *ELF* (BCME, 2008), and the *ELK* (OME, 2010) contributed to our development of *dimensions* for each aspect and of *indicators* that would provide evidence of such dimensions as they were enacted in an ECE classroom. We also drew heavily upon the EQUIP protocol (Marshall et al., 2009) and utilized materials from Early Childhood Hands-On Science (ECHOS®), a science curriculum that emphasizes fundamental science concepts and science process skills (Patricia and Phillip Frost Museum of Science, PPFMS, 2014). Additionally, we referred to the provincial science curriculum documents from British Columbia and Ontario. For example, for the Play aspect, we drew directly from both the *ELF* (BCME, 2008) and *ELK* (OME, 2010) documents, using key phrases in the COP. Phrases such as *communicate by talking, listening and writing; explore recognize, describe and create patterns; use technological problem* solving and *discussing ideas, sharing finding* were all integrated directly into the COP.

Using these documents and taking into account the realities of the classroom environment, we designed a preliminary COP for STEM learning at the early childhood level. The process of deciding upon aspects, dimensions, and indicators was as follows:

- The Questioning aspect was most influenced by EQUIP (Marshall et al., 2009).
- Exploring became part of the Play aspect, which was informed by the *ELF* (BCME, 2008) and the *ELK* (OME, 2010).

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- Observing was subsumed by the Process Skills aspect which was in turn heavily influenced by ECHOS (PPFMS, 2014) and validated by comparison with the two provincial curriculum documents.
- Communicating was also merged with Process Skills.
- A fourth aspect, Scientific and Engineering Practices, was added to the COP and appropriate dimensions for this aspect were adapted from the K-2 performance expectations of the *NGSS* (Achieve, 2013). We wanted to differentiate between process skills and science and engineering practices so that the COP could be used for both science and STEM observations.

At this stage, the COP consisted of four aspects, 16 dimensions, and three to five indicators for each dimension. For consistency and ease of use, we condensed the number of indicators so that there were three for each dimension. For example, the Predicting dimension in the Process Skills aspect was drawn from ECHOS (PPFMS, 2014) and initially consisted of five indicators: *verbalizing thinking*, *recognizes and extends patterns*, *makes simple predictions*, *makes predictions based upon observations*, and *uses estimates to make quantitative predictions*. Because we already had an Observing dimension, we reduced the number of indicators to four: *verbalizing thinking*, *recognizes and extends patterns*, *makes simple predictions*, and *uses estimates to make quantitative predictions*. Then, since the concept of qualitative and quantitative were already addressed in the Math and Computational Thinking dimension, and Communicating subsumed *verbalizing thinking*, we further reduced the number of indicators to two: *recognizing and extending patterns*, and *making simple predictions*. The third indicator for the Predicting dimension, *comparing predictions to what actually occurred*, came from the *NGSS* (Achieve, 2013).

We piloted our initial COP and refined it for clarity, added items that classroom use suggested should be included, and removed indicators that were duplicated across dimensions. After piloting, we added a code number to each indicator to enhance the usability of the COP, making observations more efficient because only the code would need to be recorded, rather than a description of the indictor. Ease of use was essential because our expectations of the COP were that it could and would be used in real time (i.e., while instruction was taking place).

The current COP, which is still in a trial phase and should not be used without the written permission of the authors, addresses four aspects (e.g., scientific and engineering practices) with each aspect being composed of two or more dimensions (e.g., argument). Additionally, each dimension has three separate indicators or types of behaviours that likely suggest the dimension is present (e.g., indicating agreement or disagreement based on evidence). The Process Skills aspect of the COP for ECE classrooms is presented in Table 2.

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Table 2 The Process Skills Aspect of the ECE STEM COP

	Aspect ~ Process Skills		
Dimension	**Indicators**		
Observing	Using senses to identify properties of objects	Using tools to observe objects and events	Using measurement tools to record observations
Describing	Describing key attributes of objects	Creating drawings or models depicting objects	Describing changes in objects
Categorizing	Noticing similarities and differences	Sorting objects into groups using one or more attribute	Establishing and justifying sorting criteria
Predicting	Recognizing and extending patterns	Making simple predictions	Comparing predictions to what actually occurred
Communicating	Communicating information or design ideas +/or solutions in oral +/or written forms	Sharing, listening, and discussing ideas	Communicating results and findings

Our classroom observation protocol is intended to aid in the precision and accuracy of capturing early childhood classroom behaviours, and therefore it needs to be practical for use by early childhood educators, researchers, and research assistants (RAs). We wanted to create a COP that requires minimal 'training' so that it is user friendly and classroom ready; teachers will be able to use it without the extensive training that some other COPs require. For example, CLASS requires intensive training before a reliability test is taken by data collectors (Le Paro et al., 2004). The initial steps of developing this COP involved both of the researchers over a series of sessions in the Pre-K classroom creating, piloting, editing, and re-testing the tool. The early childhood educators were not involved in the creation or early revisions of the COP and only began to work with it after we had finalized the current version, because we wanted to provide them with a tool that we deemed workable without overwhelming them with the many changes that occurred in the initial stages of development.

We asked the early childhood educators to use the COP along with a parallel lesson planning template (see Figure 1) that highlighted the dimensions and indicators the lessons were intended to demonstrate. We also asked the educators to reflect on their lesson plans using the parallel template. There was an initial resistance to the use of the COP from one educator, because her preferred approach to collecting classroom data was anecdotal running records. She also expressed a sense of discomfort arising from 'forcing' children into the actions and behaviours described in the COP. However, after we emphasised that the COP was tied directly to both the lesson planning and lesson reflection templates, and reinforced that this tool was merely observational, with its use supplementing rather than replacing anecdotal recording, she was willing to try out the COP and the planning template.

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<table>
<tr><td colspan="2">Date:</td><td colspan="2">Topic # and Title:</td></tr>
<tr><td colspan="4">Pre-Teaching Reflection</td></tr>
<tr><td colspan="4">Intended Dimensions of emphasis:</td></tr>
<tr><td colspan="4">Possible challenges:</td></tr>
<tr><td colspan="4">Post-Teaching Reflection</td></tr>
<tr><td colspan="2">How the lesson went:</td><td colspan="2">Evidence:</td></tr>
<tr><td colspan="3">Evidence of (Indicator) during STEM instruction</td><td>Actual Dimension enacted</td></tr>
<tr><td colspan="3"></td><td></td></tr>
<tr><td colspan="3"></td><td></td></tr>
<tr><td colspan="3"></td><td></td></tr>
<tr><td colspan="3"></td><td></td></tr>
<tr><td colspan="4">How the lesson successfully addressed the intended Dimensions:</td></tr>
<tr><td colspan="4">Changes to make to lesson plan and instruction (e.g., to build on unanticipated strengths or address noted challenges):</td></tr>
<tr><td colspan="4">The best thing (just one!) that I saw or thought about this lesson:</td></tr>
</table>

Figure 1. The ECE pre and post lesson reflection template.

After this initial reticence, the feedback from the early educators on the use of the COP (combined with the lesson and reflection templates) was positive. Both educators were very happy with the linkage between the COP and the lesson reflection template as the benefits of this connection (i.e., reduced time in planning lessons and completing the lesson reflection template, ability to quickly capture classroom behaviours) became immediately apparent to them. In fact, when asked to talk about the COP, the educators commented that "It was extremely helpful in [our] planning and assessment of the activities [that we were doing in the classroom]. It was rich and not cumbersome to use once we became comfortable with it. Numbers for identification of dimensions and aspects was useful." They also commented that "It helped us identify and name the STEM skill that the children were exhibiting and those attributes we were looking for. It helped us to be more intentional with our planning. It gave us a road map for assessment."

In an effort to increase the precision and accuracy of the use of the COP in the classroom for early childhood educators to plan and evaluate their lessons, as well as enable use by other researchers, we developed descriptors and exemplars of what these indicators might look like in practice. The ease of use of the COP was enhanced when all members of the research team were provided with brief descriptors and examplars for each indicator. An example of the flow from aspect to exemplar for each of the four aspects is shown in Table 3.

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Table 3 Sample Descriptors and Exemplars for Indicators on the ECE STEM COP

Aspect	Dimension	Indicator	Descriptor and Exemplar
Questioning	Characteristics and Nature	Q-1 Range of purposes: remember, understand, apply, analyze, create, evaluate	The emphasis is on the function of the question and the kind of response that the question is intended to encourage, i.e., in a particular context a variety of question types are asked, e.g., "Who remembers...?", Why do you think...?
Play	Pretend	P-3 Making mental representations	using imagination; using one item in the place of another, e.g., while building with blocks a child comments "I am making a house for my friends"
Process Skills	Categorizing	PS-8 Sorting objects into groups using one or more attribute	Buttons can be sorted by shape, but also by color, number of holes, material, etc.
NGSS Scientific and Engineering Practices	Argument	SEP-14 Indicating agreement or disagreement based on evidence	A student agrees or disagrees with a claim and explicitly refers to relevant previous experiences ("I agree that this object will float because it is squishy and full of holes like a sponge, and a sponge floated")

Our next step was a validation process that addressed the validity and reliability of the COP. We needed to identify which dimensions and indicators required revisions and which descriptors needed rewriting. Through this process we would also be able to determine whether the training process was sufficient for future scale-up.

Validity and Reliability

The first basic property of empirical measurements is validity (Watkins & Pacheco, 2000). The criterion-related validity of the ECE STEM COP (i.e., connections between the external behaviours and the measuring instrument itself) can be assessed by how well the COP is linked to the numerous policy, government publication and curricular documents referenced in its creation (Carmines & Zeller, 1979), in particular the *NGSS* (Achieve, 2013), the *ELF* (BCME, 2008),and the *ELK* (OME, 2010). Our arguments for criterion-related validity, and by extension support for the appropriate interpretations from the results of this tool, rest upon the details provided in this article for the design of the COP.

With the validity of the COP established, the second basic property of empirical measurement (reliability) had to be determined (Watkins & Pacheco, 2000). In this instance, inter-rater reliability (IRR) was the appropriate calculation. However, there is little consensus about the best statistical measures for determining IRR for COPs despite agreement that reliability is critical for development and that it is demanded by funding agencies (Rui, 2009). Faced with this lack of consensus, we chose Cohen's kappa coefficient ($\varkappa$) as our measure of IRR because it compares the observed agreement between two raters with the agreement expected by chance alone (Hallgren, 2012) which made the calculation particularly appropriate given our validation process, which involved coding of video clips by multiple members of the research team.

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To calculate the IRR we video recorded two STEM lessons in the Pre-K classroom and then segmented the recordings into nine shorter clips. The nine clips followed natural breaks and transitions in the lessons and were approximately five minutes in length. We assigned six different video clips to each member of the research team, ensuring that each clip was coded four times, as shown in Table 4. Additionally, each rater coded the same clip as each other rater at least three times to allow pairways comparisons. For example, both Researcher 1 and Researcher 2 coded Clips 1, 2, and 9.

Table 4 Assignment of Video Clips for Calculating the Reliability of the ECE STEM COP

	Video Clip								
Rater	1	2	3	4	5	6	7	8	9
Researcher 1	X	X	X		X		X		X
Researcher 2	X	X		X		X		X	X
ECE Teacher 1		X		X	X	X		X	X
ECE Teacher 2	X		X	X		X	X	X	
Research Assistant 1		X	X		X		X	X	X
Research Assistant 2	X		X	X	X	X	X		

We examined the agreement between pairs of raters on each video clip. Our approach was to compare the observer reliability on all the 48 indicators in the COP and to calculate $\varkappa$ values for each pair. For example, for each occurrence of an indicator raters could (i) choose the same indicator, (ii) choose no indicators, (iii) rater A could choose an indicator when rater B did not, or (iv) rater B could choose an indicator when rater A did not. To facilitate the pairways comparisons, we broke the video clips down into 10 second segments, determined the instances of rater agreement for each segment, and then totalled the instances. For example, Researcher 1 and RA 2 had the following results: (i) both raters indicated the same code 17 times, (ii) both raters did not indicate 4 times, (iii) rater A indicated 1 time when rate B did not, and (iv) rater B indicated 6 times when rater A did not. Using these data we will be able to calculate the percentage agreement as well as $\varkappa$ between all sets of raters. Initial results of the comparison are provided in Table 4.

Table 4 Partial Output for COP Rater Tasks Selection for Individual Videos

Video Clip	**Raters**	**# Agreement**	**Total Tasks**	**% Agreement**	**Kappa ($\varkappa$)**
1	Researcher 1 and Research Assistant 2	21	28	0.75	0.40
4	Researcher 2 and Research Assistant 2	53	68	0.78	0.41
5	Researcher 1 and Research Assistant 2	48	60	0.80	0.44
9	Researcher 1 and Researcher 2	14	18	0.78	0.41

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Despite the fact that ϰ has not been calculated for the remainder of the video coding, a few general statements on the reliability of the COP can be made. For example, a rough estimate of the percentage of agreement (i.e., expressed as the number of agreements in observations divided by the total number of observations) was calculated for two raters across the first video at 75%. Additionally, ϰ for those same set of raters was .40. Interpretation of ϰ is straightforward as it takes the form of the common correlational coefficient (i.e., bounded range of +1 to -1). Values of less than .40 are poor, values of .40 to .60 suggest fair agreement, values of .60 to .75 represent good agreement, and values greater than .75 indicate excellent agreement (Watkins & Pacheco, 2000). All calculations for % agreement and ϰ will be performed as above, once all raters have completed coding their video clips.

What is perhaps of more interest than how often raters' codes were in agreement is the areas where differences in coding were observed. The areas appearing problematic (i.e., perhaps requiring revision of the COP or more attention to training) were within the aspects of Questioning (e.g., range of purposes versus level of question) and Process Skills (e.g., simple predictions versus communicating information) and between indicators in the aspects of Play and Process Skills (e.g., making observations using all senses versus noticing similarities and differences). The analysis of smaller segments is helping to aid in our identification of problematic indicators, for example, areas of overlap both within and between aspects of the COP. Our plans to refine the ECE STEM COP include addressing all areas in which IRR is low, which will result in a more useful and reliable tool for both teachers and researchers in ECE.

Discussion and Next Steps

This paper presents the initial phases of a study that - through the combined efforts of two researchers and two early childhood educators, not to mention a classroom of young learners and their parents and guardians - is exploring how STEM principles might be effectively implemented in an early childhood learning environment. The questions that guided us in the initial phases of the study included (i) What are the aspects of effective ECE STEM instruction? and (ii) How can we gather evidence of those aspects? In an effort to gather data towards uncovering answers to these questions, we designed and are currently validating a COP that can be used to collect information about the nature of STEM instruction within an ECE classroom. The COP has been piloted for use in conjunction with a lesson planning and reflection template to offer a clearer view of the STEM teaching and learning occurring in the Pre-K classroom and to provide feedback for the early childhood educators on teacher and student interactions during STEM lessons. The reflection template (i.e., Figure 1) is already in place and being used by the early childhood educators, the next step is to implement it as a planning tool in their practice.

STEM is at the forefront of current educational debate and thus exploring STEM programs in ECE is both a timely and potentially fruitful pursuit. There are a number of uses for the COP and the data that it can generate. For example, it is suggested that students at the ECE level need STEM experiences that will help them develop their intellectual capabilities (cf., NSTA, 2014). The COP could assist early childhood teachers to plan STEM experiences and ensure that such experiences are in fact taking place in their classrooms, particularly when combined with the lesson planning and reflecting template. The COP can also be utilized to identify STEM indicators that are not evident throughout lessons and activities, and thus providing teachers a non-threatening tool for teachers to analyze and adjust their planning and instruction to promote these indicators.
This COP, although still in development, enables us to broadly capture the behaviours of ECE students in the context of STEM education. The aspects, dimensions, and indicators of the COP

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were adapted from a number of public, policy, and governmental documents associated with science education, STEM education, and ECE. We designed the COP based upon documents that (i) were recent within the literature around science and STEM education, (ii) were relevant to the geographical location of the study, and (iii) offered guidelines for assessing the ECE environment. The aim is that the COP will be a viable research and teaching tool, aiding researchers in collecting data and helping early childhood educators to plan, implement, and reflect upon their STEM practices. There is an obvious economic argument for effective ECE STEM programming as nations seek to compete in the knowledge economy; however, the significance of effective programming should go beyond economics. STEM education is not just for those students who will pursue post-secondary education or careers in STEM-related fields. A population with a foundation in STEM will be better prepared to face the challenges of a science and technology driven society (NRC, 2011).

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