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ABSTRACT
This article reports and compares results from an interview study of early childhood teachers in the U.S. and Hong Kong, with a focus on the math outcomes that children may gain from play with unit blocks. Teachers were interviewed to obtain their ideas of the benefits of unit block play in three focal areas: geometry, measurement, and numeracy. Hong Kong teachers contributed significantly more unique ideas than did U.S. teachers in both numeracy and in general math processes, and in the overall number of different math-related ideas. No significant differences between teachers were found in ideas about the benefits of unit blocks for learning in geometry or measurement. Cultural comparisons of teacher knowledge with respect to a wider array of the mathematical concepts that children learn from unit block play may increase our understanding of math knowledge that teachers need in order to facilitate math learning from block play.

Introduction
Long before they enter preschool, children’s explorations of their everyday environments contribute to their developing understanding of concepts such as number and shape, setting the stage for later formal learning of mathematics. As more is understood about children’s early math abilities, increased attention has been paid to factors that may influence their early learning, including cultural factors and quality of early childhood teaching.

Educators and researchers in both the United States (National Research Council [NRC], 2009) and in Asia (Cheng & Hsu, 2016), have expressed concerns about factors that may predict differences in early math learning between disadvantaged and more advantaged children. In the United States (U.S.), interest in early math also stems from the consistent differences in math achievement between U.S. students and those from Asian countries. Cross-national comparisons on the Trends in International Mathematics and Science Study (TIMSS) indicate that, by 4th grade, children in the U.S. are already behind Asian students in their levels of achievement in math, and these differences remain through high-school (Mullis, Martin, Foy, & Hooper, 2016). Smaller-scale comparisons indicate that differences may be present even before children enter kindergarten (Miller, Kelly, & Zhou, 2005). Coupled with growing understanding of young children’s mathematical abilities and potential, such differences have spurred increased attention to both the what and the how of early math teaching in the U.S. and in Asia, including in Hong Kong (HK). This article aims to explore potential contributors to these later differences by conducting a cross-cultural comparison of how early childhood teachers in...
the U.S. and Hong Kong perceive math outcomes that children may gain from play with unit blocks, a material present in many classrooms in both locations.

In both the U.S. and HK, learning outcomes and standards have been established for early math teaching. Focal areas identified by the National Council of Teacher of Mathematics (National Council of Teachers of Mathematics [NCTM], 2006) for math learning in Kindergarten and beyond include: numeracy (e.g. number sense, quantity, operations), geometry (e.g. shapes, spatial relationships), measurement (e.g. regularities in length and height), pattern and algebraic thinking (e.g. repetition, regularity, prediction), and data display and analysis (e.g. collecting, organizing, representing). Researchers have outlined learning trajectories that describe how these important outcomes emerge over time in young children (Sarama & Clements, 2009). Three of these areas (numeracy, geometry, and measurement) have been specifically targeted for the preschool years in a joint position statement by the National Association for the Education of Young Children and the NCTM (NAEYC/ NCTM, 2010), as well as by the National Research Council (NRC, 2009). Explicit attention also is paid in these sources to general mathematical processes such as problem solving, reasoning, representing, connecting, and communicating mathematical ideas (National Council of Teachers of Mathematics [NCTM], 2007), as well as to procedural actions such as sorting, grouping, and comparing (Clements, Sarama, & DiBlase, 2004).

In the U.S., many states now have early learning standards (Daily, Burkhauser, & Halle, 2010) that are based on or compatible with national recommendations. In the mid-western state in which the U.S. data for the current study were collected, early math standards are organized into the areas of number, measurement, patterns, geometry and spatial relations, and analysis of data (Illinois State Board of Education, 2013). In HK, areas of math are included in all commonly used early childhood curricula and guidelines (Curriculum Development Council [CDC], 2006, 2017; International Baccalaureate [IB], 2009; Standards & Testing Agency, UK Department of Education, 2016). The IB Primary Years Program, used by the majority of HK programmes in the current study, includes five strands: data handling, measurement, shape and space, pattern and function, and number. In each of these sets of standards and curricula, explicit mention is also made of mathematical thinking processes such as reasoning, connecting ideas and representation, and of procedural actions such as grouping and comparing. Early educators in both locations in the current study therefore have substantial guidance available with respect to important math outcomes for young children. Further, in both the U.S. and HK, exploration of concrete, manipulative materials is emphasized as a primary avenue for fostering optimal growth across many areas of development and learning (e.g. CDC, 2006, 2017; NAEYC/NCTM, 2010). In math education, manipulatives are viewed as important tools through which children develop a deeper, more abstract knowledge than through procedural learning alone. Manipulatives foster exploration of concepts within a highly engaging environment and support a reciprocal relationship between cognitive outcomes such as problem solving and emotional engagement with the materials and with math (Fisher, Dobbs-Oates, Doctoroff, &Arnold, 2012).

Unit blocks are a common manipulative material in early childhood. In the U.S., they are present in almost all early childhood classrooms. In HK, although unit blocks are less ubiquitous, they are still prominent in many early childhood programmes. Educators have long viewed unit block play as having benefits across many areas of development and learning (Hirsch, 1996). Nevertheless, unit blocks were designed specifically to elicit and encourage children to discover, practice, and learn early math concepts (Pratt, 1948/1990). Casey and Bobb (2003) listed a variety of math concepts present in block play: geometric properties, measurement, patterning, part-whole relationships, visualization, symmetry, balance, and transformation, as well as the procedural skills that children employ as they sort, classify, and estimate. During play with unit blocks children also experience the inter-relationships among different areas of math as they apply many math concepts and skills simultaneously to their block constructions (Kersh, Casey, & Young, 2008). As a spatial activity, unit block play may help establish a foundation for math in both preschool and kindergarten (Robinson, Abbott, Berninger, & Busse, 1996; Verdine et al., 2014).
Maximum benefits from block play are derived when teachers supply language and engage children in dialogue that supports knowledge of concepts and extended mathematical reasoning (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006). Joint block play may naturally elicit adults’ use of spatial language (Ferrara, Hirs-Pasek, Newcombe, Golinkoff, & Lam, 2011), which is associated with children’s spatial language and later spatial abilities (Pruden, Levine, & Huttenlocher, 2011). Further, when teachers pose dilemmas and prompt curiosity (Newcombe & Frick, 2010), they create an arena for problem solving and mathematical thinking, challenging children to think and reason beyond what they already know (Whitbread & Coltman, 2010). Thus, while unit blocks provide a natural context within which to apply and practice mathematical concepts and processes, deeper learning of math concepts may be dependent on teacher/child interaction (Casey et al., 2008), which in turn is dependent on teachers’ knowledge of the concepts and mathematical thinking processes that are available in unit blocks.

The term ‘math knowledge for teaching’ (MKT) describes the knowledge of math content and pedagogy that teachers need in order to teach early math (Ball, Thames, & Phelps, 2008). They must have age appropriate expectations, select and sequence learning experiences and examples of concepts, anticipate and interpret what children of a particular age are experiencing and might find confusing, and respond to misunderstandings with correct information. Teachers’ MKT affects the math achievement of their students (Hill, Rowan, & Ball, 2005). However, in many early childhood classrooms, play with unit blocks remains primarily a free choice activity unsupported by teachers, and intentional use of block building to teach math is rare (Casey et al., 2008; Kersh et al., 2008). Teachers may even be unaware of the block building abilities of specific children in their classrooms (Eberly & Golbeck, 2001). Thus, it is important to understand how teachers perceive unit block play and their own roles in supporting it.

**Early math in unit blocks: literature review**

Research on math concepts learned from unit blocks play is limited. Further, it is focused largely on geometry, rather than the full range of focal areas for early childhood math. However, it does offer evidence of relationships between unit block play and two geometric outcomes (complexity of construction, and spatial awareness). This research also establishes relationships between geometry and more general math skills.

Based on observations of young children playing with blocks, early researchers such as Johnson (1996) and Guanella (1934) described sequential, hierarchical stages of complexity in block building. For example, Johnson outlined age-related stages of complexity that included carrying; simple repetition (rows or stacks); bridging; enclosures; pattern and balance; and representation. Hanline, Milton, and Phelps (2001) combined several conceptualizations of complexity into a 19-level scoring system to describe observed block play of preschoolers with and without disabilities over a 3-year period. Block play occurred during morning centre time, with teachers introducing the experience by emphasizing some aspect of block play (e.g. type of construction, location words). Results indicated that all children progressed through the same levels of complexity, even though children with disabilities lagged behind their peers. Further, the amount of time that children spent in block play was associated both with growth rates and with final levels of complexity achieved, indicating an effect for experience.

Gregory, Kim, and Whiren (2003) demonstrated that stages of complexity in block constructions were not only developmental but also responsive to adult support. After student teachers in an early childhood lab-school setting were taught to recognize three dimensions of complexity (stage, use of arches, and dimensionality), the researchers asked them to join children in the experimental group as they played with unit blocks, to encourage problem solving, and to facilitate children’s play through verbal scaffolding directed toward moving children toward a more complex level of play. Children in the comparison group played with blocks as usual. The results indicated that teachers could influence children’s understanding of dimensional complexity by pointing out important
features and engaging children in thinking about their constructions. Given support that emphasized a higher level of complexity in their constructions, children were able to demonstrate these higher levels independently.

Spatial awareness, another common outcome in studies of unit block play, also is influenced by experience with spatial materials. For example, based on parent report, Jirout and Newcombe (2015) found that spatial reasoning as measured on a block design test was related to the amount of time that children played with toys such as blocks and puzzles. A small number of experimental studies also have explored the relationships between play with construction materials (including unit blocks) and spatial skills. Sprafkin, Serbin, Denier, and Connor (1983) randomly assigned children to an experimental condition that utilized ‘masculine’ toys (e.g. tinker toys, blocks) and to a control condition. Training sessions based on these toys instructed children how the materials could be used, showed relevant features, and encouraged children to make structures using the materials. Children then played with the materials on their own during free play. Results demonstrated significant change at post-test in the experimental group, indicating a causal relationship between children’s play with construction toys and performance on specific spatial tasks.

Early skills with manipulatives also predict more general mathematical ability. Verdine et al. (2014) identified early links between different aspects of spatial reasoning and early math skills using a construction material with interlocking parts (Legos) and a structured 3-dimensional model-copying task. Models were designed for increasing difficulty (e.g. number of pieces, vertical location, rotation). Children were 3–4 years old, and represented different socio-economic (SES) levels. Outcome measures included a modified standardized spatial task utilizing the model-copying task as well as an early math assessment. Spatial assembly skills accounted for a significant portion of the variability in early math skills. In a later, longitudinal study of children from 3–5 years old, Verdine, Golinkoff, Hirsh-Pasek, and Newcombe (2017) directly studied the development and relationship between spatial reasoning and math, using 2- and 3-dimensional spatial materials such as Legos and tangrams. Spatial skills at age 3 were highly predictive of those at age 5; in addition, spatial skills at age 3 were highly predictive of math skills at age 5. Results were interpreted as being consistent with a causal pathway in which improving spatial skills led to improving mathematical skills.

In summary, while this body of research is not extensive, it indicates that there are important inter-relationships between and among block play, different spatial skills, and mathematics. Spatial skills developed during play with blocks and other materials appear to have a causal role in achieving more advanced math skills (Mix & Cheng, 2012; Verdine et al., 2017). Intentional use of block play to support complexity of construction and spatial skills may not only increase these skills but also impact children’s early math learning. Teachers who understand the dimensions of complexity in children’s early block constructions, as well as the spatial skills involved in children’s structured and unstructured block play, may be more likely to provide appropriate opportunities and supports for complexity and spatial learning than teachers without such knowledge.

Missing from this research using unit blocks and similar materials is a consideration of a broader range of the mathematical knowledge and skills that young children may gain from their block play in addition to geometry. This lack of knowledge has implications for understanding what teachers should know about a wider array of early math learning opportunities that may be provided by unit blocks. A study of teachers’ interpretations of what children gain from block play can provide a window into a more complete understanding of the math knowledge for teaching that should become a part of early childhood teacher thinking and teacher preparation. Cross-cultural comparisons may provide additional insights. Ma (2010) concluded that the Chinese teachers in her study of U.S. and Chinese early childhood teachers had a deeper and more internally coherent mathematical knowledge of numeracy than their U.S. counterparts, which supported their ability to more accurately and flexibly explain mathematical ideas to their students. She speculated that this may have been due at least in part to differences in teacher education. Exploring similarities and differences in teachers’ thinking across cultures may lead to a richer understanding to support teacher education and
further research, as well as reveal areas of research that may further our understanding of cultural differences in math achievement.

This article reports and compares results from an interview study of early childhood teachers in the U.S. and HK, with a focus on the broad range of math outcomes that children may gain from play with unit blocks. The primary research question was: (1) What are the similarities and differences between U.S. and HK teachers with respect to benefits of unit block play for learning outcomes associated with the early childhood focal areas for math? To place ideas about math within the context of other ideas about the benefits of block play, a secondary research question was: (2) How do teachers in the U.S. and HK describe math benefits of block play within the broader range of benefits that children derive from unit block play? Also of interest was how patterns of responses were related to standards and outcomes for early math learning found in early childhood research and other professional literature.

Methods

Participants

Early childhood teachers from HK (n = 10) and from the U.S. (n = 12) were recruited by the authors from local kindergartens (HK: defined as ages 3–6) and preschools (U.S.: defined as ages 3–5). All U.S. teachers taught children from 3–5, whereas nine HK teachers taught 3–5 year olds and one taught 5–6 year olds. Over half of the teachers in each research site had more than five years of early childhood teaching experience (range: HK, 2–29 years; U.S.: 1–33 years). All teachers with the exception of one HK teacher, who had 2 years of college, had completed a minimum of a bachelor’s degree. All U.S. teachers held certification for preschool, required in this mid-western state. Four HK teachers held pre-k or kindergarten certification and were registered with the HK Education Bureau. Only two teachers from each research site indicated they had taken courses in preschool math teaching during their teacher education programmes.

All U.S. teachers taught in public school preschool classrooms located in 3 different buildings within the same geographic area. All classrooms were required to address the Early Learning and Development Standards (ELDS) outlined by their state (Illinois State Board of Education, 2013) and to document children’s progress in relation to these standards. None of the teachers used a separate math curriculum. In HK, all Kindergartens (KGs) are privately operated but are under the supervision of the Education Bureau. In the current study, five teachers taught in what are called private non-profit making KGs and five in what are called private independent KGs. Nine worked in KGs that used a non-local curriculum such as the IB Primary Years Program (International Baccalaureate, 2009), and one used the local CDC curriculum (2006).

Descriptive information on how these teachers used unit blocks in their classrooms indicated that all U.S. teachers had block centres in their classrooms, available to children daily during free-play time. Blocks were stored in low shelves that children were able to access independently during free play, and objects to use with the blocks (e.g. transportation toys, small people, animals) were also available within the centre. Of the ten HK teachers, four had similar set-ups. In the other classrooms, while blocks were available to children during free play, availability ranged from daily to 2–3 times per week, and in one classroom were available once per month. Due to limited space in the classrooms, children either brought the blocks to a designated play area, or teachers brought the blocks to a play area or to the classroom when children requested them. In both research sites, teachers described block play as self-selected and as involving between 3–5 children at a time.

All teachers were recruited via a survey used in a previous project on teacher beliefs (unpublished). A final question on that survey asked teachers whether they had unit blocks in their classrooms and whether they would be interested in participating in a study of unit block play. All U.S. teachers who had completed the survey (n = 12) reported having unit blocks whereas ten of the HK teachers reported having them. All of these teachers were contacted and subsequently gave consent to participate in the current study, following procedures for human subjects approved in each site.
Instrumentation

A structured but relatively open-ended interview protocol was used to obtain teachers’ ideas of the benefits of unit block play for math learning. The interview began with having the teachers confirm that they used unit blocks in their classrooms. The main part of the interview was divided into three sections. The first included general questions about the benefits of unit blocks (‘what benefits do you think children gain from their play with unit blocks?’), without any specific focus on math. A hypothetical situation was presented to help teachers articulate these benefits: ‘If you were going to try to convince your administrator to purchase some unit blocks for you, what benefits would you list?’ The interview then moved to a second section in which teachers were specifically asked about benefits for math learning (‘let’s look more specifically at benefits related to math’). In the third section, teachers were presented with the three focal areas of early childhood math (NCTM, 2006). The words numeracy, geometry, and measurement were written on cards that were shown to the teachers; these were left available as reminders until the end of the interview. In each section of the interview teachers were given probes to expand on or add new ideas until they indicated they had no more to add. At the end, the hypothetical administrator was again referred to, and teachers were asked one final time if there was anything else they would like to tell their administrator. The interview, initially developed in English, was translated into Chinese for use in HK, and then back-translated to ensure consistency across the two versions. Based on this process, specific language to use in the interview was revised where needed.

Data collection

Interviewers in each site were trained by the authors. Each interviewer practiced conducting the interview with one of the authors until she achieved 100% fidelity to the interview protocol. Each was then given feedback on fidelity on the first three interviews or until she had maintained at least 90% fidelity to the protocol on at least two interviews. Two additional interviews were also selected randomly from the remaining interviews and checked for fidelity. In HK, the average fidelity ranged from 72%–100% (mean: 93%), and in the U.S. from 88%–100% (mean: 97%). Lower fidelity all occurred in the earliest interviews, and was explained primarily by the interviewer forgetting to ask if there was anything else the teacher would like to add. Interviews were conducted at a time and location that were convenient for each participant, and were audio-recorded. Interviews lasted approximately 25–45 minutes. Participants in HK had the option of being interviewed in either English or Chinese. Audiotaped interviews were then transcribed by native speakers at each site. Transcripts were checked against the audiotapes for accuracy by a second individual and corrected if needed. If the interview was conducted in Chinese, back-translation was completed and translations also were checked for accuracy.

Data coding

Codes

Two sets of codes were used. The first set was designed to capture teachers’ ideas about math benefits from unit block play, to address the primary research question. The coding form included the three areas of numeracy, geometry, and measurement, based on recommendations from the NCTM (2006) for focal areas in early childhood math. Each of the focal areas was then further divided into subcategories representing both concepts (content knowledge) and actions (application of procedures), based on a variety of published sources in both the U.S. and HK (e.g. recommendations, standards, curricula, teaching guides). Complexity of block construction and spatial relationships, addressed in previous research on early block play, were both included as sub-categories under the broad area of geometry. Finally, benefits that referred specifically to math processes but were not linked directly to one of the three focal areas were coded separately as categories under general math
processes (e.g. communicating math ideas, connecting areas of math). Subcategories were included to provide a picture of the range and richness of benefits identified within each focal area.

The second set of codes addressed the second research question, i.e. how teachers perceived the math benefits of block play as compared to other benefits, and was included to set the context for interpreting teachers’ views about math. Categories for non-math benefits were based on a combination of published teachers’ guides outlining the benefits of unit block play across multiple areas (e.g. social, emotional, language, cognitive, academic) as well as on benefits that emerged from the interviews.

**Coding process**

All interviews were read by both authors, using the English versions of the transcripts. Each author first read and coded the transcript separately. Using several levels of coding, transcripts were first read to identify any instance where the teacher was talking about a benefit from block play and to designate it as a math or non-math benefit. Second, each math benefit was coded into one of the focal areas and then into one of the subcategories; if a more general math process was mentioned that had no obvious reference to a specific focal area, it was coded under one of the general math process subcategories. The coders also kept track of where in the interview each benefit had been mentioned (i.e. before any probe, after the general probe about math, or after the probe about three areas of math). In addition, the coders designated each tally as either a new idea or as a repetition of an idea already talked about by that teacher. A similar process was followed with respect to non-math benefits from block play except that the authors did not track where in the interview it occurred since no probes were used to address non-math benefits. Following individual coding of each interview, the authors met together to discuss the interview and reach consensus on the placement of each benefit. All data therefore represent consensus on the appropriate placement of each benefit named by each teacher, whether or not the response was spontaneous or in response to a probe, and whether it represented a new or repeated idea.

**Data summaries**

Math data were summarized for each teacher using frequency of new, unique ideas within each of the three probe conditions as well as across probes, and for each sub-category within each of the focal areas. Ideas about general math processes were tallied and summarized in the same way. To support visual analysis of patterns in the data, individual summaries were combined into a group summary for each of the U.S. and HK teachers. To aid in interpretation of the primary results, a separate summary of math benefits was also developed indicating the number of teachers who had contributed to each of the codes under each probe condition as well as overall, for use in visual analysis. Non-math benefits also were summarized for visual analysis based on the number of teachers contributing to each category.

**Results**

**Math benefits of block play**

**Preliminary analyses**

The primary aim of this study was to describe and compare HK and U.S. teachers’ ideas about the math benefits that young children gain from their play with unit blocks. Two initial analyses were undertaken before addressing the first research question. First, a summary table was developed to display the total number and percent of unique math-related benefits generated by teachers in each group in each of the three primary focal areas and in general math processes (see Table 1). In both groups, the focal area in which the largest percentage of new ideas were expressed was geometry. In HK, this was followed by numeracy and then measurement. In the U.S., the order was slightly different, with geometry being followed by measurement and then numeracy. Further, the HK
teachers contributed more unique ideas than the U.S. teachers both in general math processes and in two of the three focal areas (numeracy and measurement), resulting in a considerable difference in frequencies of unique ideas in the two groups.

A second preliminary step was undertaken to determine the effect of probes on the frequency with which teachers offered new ideas. Results indicated that the addition of probes helped both groups of teachers think about benefits they had not thought of before. Paired t-tests within each group, comparing new ideas before and after the addition of probes, indicated that HK teachers had significantly more new ideas related to measurement after ($M = 4.40, S.D. = 2.91$) as compared to before the probes ($M = .30, S.D. = .95$), $t(9) = 4.04, p = .00$. For U.S. teachers, probes made the most difference in unique ideas about numeracy, with significantly more ideas after the math probes ($M = 1.92, S.D. = 1.24$) than before ($M = .67, S.D. = .65$), $t(11) = 3.36, p = .01$). Probes did not significantly influence the frequency of new ideas about the geometry benefits of block play in either group.

**Primary analysis**

The first research question was addressed using T-tests to compare the average number of new, unique ideas generated by teachers in the two groups. As shown in Table 2, HK teachers had a significantly greater number of unique ideas about the benefits of block play for learning about numeracy. There was also a significant difference in favour of the HK teachers in the number of unique ideas related to general math processes. No significant group differences were found for either geometry or measurement. Overall, when focal areas were combined, and when all math benefits were combined, the HK teachers identified significantly more math benefits from block play than did the teachers from the U.S.

**Follow-up visual inspection of sub-categories**

Also of interest in this study was the extent to which teachers’ responses were in line with early math standards and outcomes described in the literature, as represented in sub-categories within each of the focal areas and in general math processes. Based on visual inspection of summary tables, we looked at the number of subcategories in which benefits were identified within each focal area. We also looked for categories in which benefits were identified by at least half of the teachers in

<table>
<thead>
<tr>
<th>Area of benefits</th>
<th>HK f</th>
<th>percent</th>
<th>U.S. f</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal areas</td>
<td>219</td>
<td>86.2</td>
<td>177</td>
<td>93.2</td>
</tr>
<tr>
<td>Geometry</td>
<td>109</td>
<td>42.9</td>
<td>112</td>
<td>58.9</td>
</tr>
<tr>
<td>Measurement</td>
<td>47</td>
<td>18.5</td>
<td>34</td>
<td>17.9</td>
</tr>
<tr>
<td>Numeracy</td>
<td>63</td>
<td>24.8</td>
<td>31</td>
<td>16.3</td>
</tr>
<tr>
<td>General math processes</td>
<td>35</td>
<td>13.8</td>
<td>13</td>
<td>6.8</td>
</tr>
<tr>
<td>Total new math ideas</td>
<td>254</td>
<td>100.0</td>
<td>190</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2. Comparison of average number of new ideas by HK and U.S. teachers.

<table>
<thead>
<tr>
<th>Area of benefits</th>
<th>HK $M$ (SD)</th>
<th>U.S. $M$ (SD)</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry</td>
<td>10.90 (4.63)</td>
<td>9.33 (4.10)</td>
<td>.84</td>
<td>.40967</td>
</tr>
<tr>
<td>Measurement</td>
<td>4.70 (2.91)</td>
<td>2.83 (2.52)</td>
<td>1.61</td>
<td>.12201</td>
</tr>
<tr>
<td>Numeracy</td>
<td>6.30 (2.11)</td>
<td>2.58 (1.51)</td>
<td>4.81</td>
<td>.00010*</td>
</tr>
<tr>
<td>Combined focal areas</td>
<td>7.30 (2.09)</td>
<td>4.92 (2.02)</td>
<td>2.72</td>
<td>.01326*</td>
</tr>
<tr>
<td>General math processes</td>
<td>3.50 (1.78)</td>
<td>1.08 (0.67)</td>
<td>4.37</td>
<td>.00029*</td>
</tr>
<tr>
<td>Total math benefits</td>
<td>6.35 (1.77)</td>
<td>3.96 (1.60)</td>
<td>3.32</td>
<td>.00339*</td>
</tr>
</tbody>
</table>

Note. *$p < .05$. 

W.-Y. HSIEH AND J. A. MCCOLLUM
each group, as well as for sub-categories where there were differences between the two groups in these proportions.

In the area of geometry, with 15 sub-categories, HK teachers listed benefits in five and U.S. teachers listed benefits in eight. Over half of the teachers in each group identified shape names, size as an attribute of blocks, representing one’s own experience in construction, and sorting, matching and comparing using attributes of blocks. Not mentioned by at least half of the teachers in either group were differences between 2-D and 3-D shapes, taking different perspectives, identifying shapes in the environment, visualizing and duplicating an observed object, using transformations (e.g. slide, flip, turn), or moving to the next level in complexity of construction. Benefits named by half of U.S. teachers but not HK teachers included learning how blocks work (stacks, lines), geometric attributes of combined shapes (e.g. balance, symmetry), spatial relationships (e.g. vocabulary such as under, on), and composing/decomposing shapes. Over half of the HK teachers, but not the US teachers, identified learning attributes of individual blocks (e.g. edge, point, face) as a benefit of unit block play.

Measurement, the second early childhood focal area, had five sub-categories. HK teachers listed benefits in three categories, whereas U.S. teachers listed benefits in two. Understanding measurement tools (non-standard and standard) and learning measurement attributes such as length and height were both identified as benefits by more than half of teachers in each group; however, less than half in each group mentioned blocks or combinations of blocks as something to be measured or using blocks as alternative tools for purposes of measuring. Learning that measurement is based on using common units (i.e. number of small blocks it takes to measure the length of a truck) was mentioned as a benefit by more than half of the U.S. but not the HK teachers, whereas comparing and classifying using a unit of measure (i.e. let’s count to which has more blocks) was named as a benefit by more than half of the HK teachers but not the U.S. teachers.

In the area of numeracy, with 10 sub-categories, HK teachers listed benefits in every sub category whereas U.S. teachers listed benefits in seven. Seven subcategories were identified by at least half of the HK teachers included learning number words, 1–1 correspondence, counting, comparing quantity (e.g. less than, equal), and performing operations (e.g. add together, take away). Subcategories mentioned by less than half of the HK teachers included telling how many, subitizing, recognizing written numerals, matching sets to written numerals, and matching sets to spoken numerals. In the group of U.S. teachers, only one sub-category (counting) was mentioned as a benefit by at least half of the U.S. teachers.

Among the 10 sub-categories included under general math processes (i.e. process benefits that were not mentioned in conjunction with any focal area), HK teachers listed benefits in nine subcategories whereas U.S. teachers listed benefits in three. Two benefits were mentioned by more than half of the HK teachers as benefits of unit block play; these included using math language, and organizing and sequencing (primarily patterning). No general math processes were identified as benefits by more than half of the U.S. teachers.

Non-math benefits of block play

To provide a context for interpreting teachers’ ideas about math benefits of unit block play, the second research question addressed the extent to which teachers also talked about non-math benefits of block play. Table 3 illustrates the percent of teachers spontaneously mentioning different kinds of benefits anywhere during the interview. Even before the math probes, every teacher in each site (100%) spontaneously talked about math benefits. As shown in the table, benefits for social interaction were spontaneously mentioned by at least 90% of teachers in both sites. Language development, creativity, and other content areas such as social studies, literacy, and music were also named by at least half of the teachers in each group. Differences between groups were especially evident in two areas: motor development (70% of teachers in HK, 17% in the U.S.), with more HK teachers talking about fine or gross motor benefits; and dispositions that children learn from unit block play (50% of
teachers in HK, 8% in the U.S.). Examples included the ability to focus on their work, the habit of checking their own work, and paying attention to details. A third area with some difference between groups was related to subject matter content areas other than math (70% in HK, 83% in the U.S.); in particular more U.S. teachers talked about benefits for learning what might be described as social studies (e.g. learning about neighbourhoods and houses).

Discussion

The purpose of this study was to describe and compare teachers’ ideas about the math learning benefits of unit block play in two cultural settings, the U.S. and HK, that by elementary school age differ significantly in students’ math achievement (TIMSS). The study was designed to provide a window into teachers’ thinking about a broad range of possible math benefits of unit block play in order to both stimulate thinking of researchers and policy-makers about linkages between construction materials and standards and curricula in early mathematics, and to identify areas for improvement of teacher education in the U.S. and in HK. Also of interest were teachers’ perceptions of math benefits within the context of their perceptions of other, non-math benefits. Teachers identified many types of benefits. However, math benefits predominated, while more benefits were identified in geometry, teachers saw benefits for all focal areas of early childhood math, as well as for mathematical thinking, particularly when probed. Among these areas, a significant difference between groups was focused only for numeracy, with HK teachers naming more different benefits than U.S. teachers. Within each group, teachers varied greatly in the number of different benefits described in each focal area and in mathematical thinking.

Math benefits

Results for math outcomes will be discussed in relation to each focal area of early childhood math and for math thinking processes.

Geometry

The NRC (2009) defined geometry as awareness, visualization, and study of shapes and space, including both two- and three-dimensional space. Unit blocks are primarily a spatial material. It was therefore not surprising that, in both groups, the focal area of geometry contained the most different ideas about benefits from block play. No significance between groups was found in this area and probes about math made little difference in the number of different ideas. In both groups, the number of sub-categories coded was relatively small, indicating that most teachers were focused on only a few types of benefits for geometry learning. The sub-category with the most ideas, and to which most teachers contributed, was naming shapes. These findings are in line with observations of other researchers (e.g. Clements & Sarama, 2011) that teachers tend to focus on shape naming rather than complex outcomes such as the geometric features of a particular shape. Further,

<table>
<thead>
<tr>
<th>Area of benefits</th>
<th>HK (n = 10)</th>
<th>U.S. (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure/experience blocks/environment</td>
<td>1, 8</td>
<td>1, 8</td>
</tr>
<tr>
<td>Social/social interaction</td>
<td>9, 92</td>
<td>11, 92</td>
</tr>
<tr>
<td>Emotions</td>
<td>4, 17</td>
<td>2, 17</td>
</tr>
<tr>
<td>Language development/communication</td>
<td>7, 75</td>
<td>9, 75</td>
</tr>
<tr>
<td>Creativity/imagination</td>
<td>8, 75</td>
<td>9, 75</td>
</tr>
<tr>
<td>Cognitive development/problem solving</td>
<td>4, 42</td>
<td>5, 42</td>
</tr>
<tr>
<td>Motor development</td>
<td>7, 17</td>
<td>2, 17</td>
</tr>
<tr>
<td>Content areas</td>
<td>7, 83</td>
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</tr>
<tr>
<td>Learning dispositions</td>
<td>5, 8</td>
<td>1, 8</td>
</tr>
</tbody>
</table>
few teachers referred to spatial learning in general or to specific aspects of spatial learning such as dimensionality (e.g. 3-D) or visualizing and duplicating an observed object, and only a few mentioned the increasing complexity of children’s constructions as a benefit of block play. These two areas have been the most studied in research with blocks and other construction materials, and are thus those about which most is known. Spatial learning in particular is thought to be a foundation for children’s understanding of math concepts (Mix & Cheng, 2012), and is tightly interwoven within stages of complexity. Both complexity and spatial learning have been shown to be responsive to teacher support. Without awareness of these outcomes, teachers may not provide the support needed, particularly for children who may not have had experience with blocks and other construction materials.

Measurement
In measurement, children compare what is being measured to a chosen standard attribute such as length, height or weight and begin to describe the results in these terms (NRC, 2009). Unit blocks were specifically designed to be used in this way, as different blocks have specific measurement relationships to one another. Many teachers in this study either were not aware of these relationships, or did not use terminology related to standard attributes (e.g. length) in describing benefits in this area. When they did, they talked primarily about using blocks as an alternative unit of measure for describing height or length. Many fewer benefits were named in this focal area, and the number of teachers contributing was small. As in geometry, there was no significant difference between groups in this area.

Numeracy
Numeracy includes knowledge and skills related to number and operations (NRC, 2009). While HK teachers saw many numeracy learning benefits from unit block play, U.S. teachers were quite limited in their perceptions of benefits. HK teachers contributed significantly more ideas than U.S. teachers, as well as contributing ideas in more subcategories; U.S. teachers contributed ideas primarily to only one subcategory, i.e. counting. Many studies in which differences in math learning have been found between Asian and U.S. children have defined math primarily in terms of numerical learning (e.g. Mix & Cheng, 2012). The results of this study indicate that HK teachers may be more aware of opportunities to emphasize numeracy learning within the context of block play. HK teachers may also possess more knowledge in this focal area, as suggested by Ma (2010). In addition, early childhood numeracy may receive more emphasis in early childhood classrooms in Asian cultures than in the U.S. (Li, Chi, DeBey, & Baroody, 2015).

Thinking processes
General math thinking processes are heavily emphasized in math standards, policy recommendations, and curricula used in both the U.S. (e.g. NAEYC/NCTM, 2010; NCTM, 2006) and HK (e.g. CDC, 2017), as well as in teachers’ guides on block play (e.g. McDonald, 2001) and on early childhood math (e.g. Copley, 2010; Early Math Collaborative, 2014). In comparison to U.S. teachers, HK teachers mentioned significantly more unique benefits for developing general math thinking processes. Nevertheless, of 10 possible processes, only three (using and learning math language, organizing and sequencing, communicating math concepts) were named by more than half of the HK teachers. None were identified by more than half of the U.S. teachers. Many teachers in this study did not appear to make a connection between more general math thinking processes and children’s play with unit blocks. In this study, this result may have been affected by the way in which general thinking processes were coded, i.e. as benefits that could not be coded under one of the focal areas. Some thinking processes such as grouping and comparing in particular may have been affected by this coding rule, since references to processes after came up within the context of a focal area.

Overall, this study revealed that individual teachers in both sites ranged considerably in their awareness of the range of learning opportunities available within unit block play. Cross-cultural comparisons of ideas about benefits of unit block play yielded both similarities and differences, with the most prominent difference being in the area of numeracy. In both groups, probes about math were
needed to elicit a full range of ideas, indicating that teachers benefited from the opportunity to dig more deeply into their own thinking. Even with probes, many sub-categories indicated as important in the literature were either not mentioned or were mentioned by only a few teachers. Thus, as noted by Casey et al. (2008), not all teachers in this study appeared to have thought about unit block play as a math-salient context. In line with the thinking of previous authors that early childhood teachers may not have sufficient math knowledge to undergird their teaching (Ginsburg, Lee, & Boyd, 2008), many of these teachers may have lacked the broad range of math knowledge for teaching needed to identify the math learning opportunities available in unit block play (Hill et al., 2005).

Nevertheless, results also indicate that the HK teachers may have more math knowledge to bring to the context of unit block play. The same interview protocol, including use of the same probes, was used with both groups yet yielded more unique ideas from the HK teachers overall as well as in the area of numeracy. HK teachers also identified benefits in more subcategories than did the U.S. teachers. HK teachers may have felt more comfortable expressing themselves about math, or may have used the probes to dig more deeply into their knowledge. Instead, U.S. teachers often said, ‘Haven’t we already talked about this?’ As noted by Ma (2010) in her in-depth interview study of numeracy knowledge of U.S. and Asian teachers, the Asian teachers appeared to demonstrate more flexibility in their thinking and more interconnections among ideas. Despite these differences, however, many sub-categories were not addressed by teachers in either group, indicating that many could have benefitted from more in-depth training in each of the focal areas and in general math thinking processes.

Non-math benefits

Teachers’ ideas about non-math benefits of unit block play were of interest in this study primarily as a framework for interpreting teachers’ ideas about math learning. Cross-cultural comparisons identified both similarities and differences between groups that enhance our understanding of how math learning may be perceived within a larger context. For some teachers in both groups, benefits in non-math areas predominated until math probes were introduced. Almost all teachers talked about benefits for children’s social and language development. With only a few exceptions, the two groups were similar to one another and to descriptions of the benefits of block play found in teachers’ guides such as those by Hirsch (1996) and McDonald (2001). The HK teachers’ emphasis on dispositions for learning, while mentioned by only half of the teachers, may be particularly significant since self-regulation appears to be closely related to general math thinking processes as well as to dispositions toward math learning (De Corte, Verschaffel, & Op’t Eynde, 2000). An emphasis on dispositions may be another potential contributor to cultural differences in later math achievement between children in the U.S. and HK, and thus worthy of further research.

Limitations

This study has several limitations. The sample size was small. Generalization to all teachers within the U.S. and HK is therefore not possible. This study also relied on interviews; the results therefore may not represent what teachers think about or do during unit block play in their classrooms. Differences in the classroom contexts in which unit blocks were used in the two samples also may have influenced teachers’ ideas in unknown ways. In the U.S. blocks are usually available in the classroom as a choice for free play, whereas in HK classroom space is more limited and some teachers may have to bring the materials to the children. Moreover, when children have to ask for blocks, access may be limited for children who are less verbal or shy, or who might need encouragement to engage in block play. Another contextual difference that may influence the way teachers thought about block play is the heavy emphasis in the U.S. on having available, within block centres, a variety of other materials that children can use to extend on imaginary play (e.g. people, animals, vehicles) (e.g. Harmes, Clifford, & Cryer, 2015). For U.S. teachers, this may shift the focus from
constructive play to imaginary play, changing the nature of their interactions with children within block play. Observational studies would be needed to tease out some of these differences and their effects on math learning opportunities.

Another type of limitation relates to subcategories coded within the focal areas. These were drawn from a wide array of resources; while the wide range of subcategories was intentional in order to gain a broader understanding of math learning opportunities in blocks, many have not been studied within the context of block play and their relative importance for math learning is not known. A related limitation is that some subcategories could just as easily have been placed within more than one focal area, such that decisions had to be made for the purposes of coding. For example, talking about short and tall with respect to size of blocks could have been included under the focal areas of either geometry or measurement. In this study, it was coded under geometry when the teacher was focused on comparing or matching sizes and under measurement when the focus was on size as a unit of measurement.

Finally, this article addresses only teachers’ perceptions of benefits, whereas math knowledge for teaching is comprised of both content knowledge and pedagogical knowledge of how to teach particular content (Hill et al., 2005). Research related to complexity of block constructions and to spatial learning indicate that teacher guidance may be critical for furthering children’s learning (Casey et al., 2008); teachers’ ideas about pedagogy would provide a useful extension on the current research.

Implications
Unit blocks provide opportunities for rich math learning experiences and are present in many early childhood classrooms in both the U.S. and HK, yet research on the math concepts and thinking processes available elicited by unit blocks is rare. By comparing similarities and differences, cross-cultural studies can lead to a more completing understanding of a range of possible ideas than studies of one culture alone (Ma, 2010). This study points toward the need for additional research on unit block play, its benefits, the interconnections among focal areas and general math thinking, and possible links to later outcomes. The study also provides new information on a broad array of possible math benefits of unit block play and highlights similarities and differences between the U.S. and HK that may point to further study in differences in teacher education as well as to needed changes in teacher education. Teachers in both research sites ranged considerably in their knowledge of important learning opportunities available in these materials. Experiences with materials like unit blocks may have long-lasting influences on a wide range of skills, particularly when supported by knowledgeable adults (Casey et al., 2008; Verdine et al., 2017). Both opportunities and teacher–child interactions that support math learning are dependent on teachers’ knowledge and understanding of how unit block play supports early math learning, so that they can maximize the full range of learning opportunities available to children. They must see the opportunities, understand the concepts, actions, and processes they need to support, and know the math and conceptual language to support children’s learning. Attention to unit blocks, in addition to other similar materials, should be an explicit part of teachers’ education for early math teaching, to overcome the assertion made by many early childhood math scholars that early childhood teachers are poorly trained in teaching early math, and teach it poorly if at all (e.g. Ginsburg et al., 2008). Teachers may need targeted experiences with unit blocks and other common early childhood materials as they learn to foster children’s math thinking and learning during interactions with these materials. Future research should include intervention studies to achieve these teacher education outcomes, as well as studies directed toward identifying sources of differences that may lie in teacher education content and processes.

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