An argument to engage really young children in mathematics

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Although it is now more commonly acknowledged that young children can engage with mathematics, it is not as commonly acknowledged that really young children (such as those aged under three years) can engage with and think mathematically. One of the reasons for this is the inability of adults to recognise mathematics in what these young children do. This paper explores the natural curiosity and engagement young children have with mathematics and discusses everyday activities within which mathematics is evident. It then suggests three lenses that adults (such as educators, family, and caregivers) can use to help them identify mathematical ideas. In providing these lenses and encouraging adults to recognise the mathematics evident in young children's everyday activities, the argument extends to maintaining opportunities for young children to willingly engage in mathematical thinking in their everyday activities over the imposition of more formalised and academic experiences in early childhood.

Really young children (toddlers up to age three and referred to as 'young children' from this point forward) can engage in mathematical activities and in mathematical thinking (Department of Education, Employment and Workplace Relations [DEEWR], 2009). Kinnear and Whittmann (2018) state research into the mathematical understandings of children shows that these young children engage with mathematics and have mathematical knowledge, their social environments impact on their "mathematical potential" (p. 20). Appropriate mathematical education in early childhood has significant and long-term positive effects on academic success and mathematical thinking.

Young children engage with mathematical ideas in their everyday lives (Greenberg, 2012) and likely do not have the aversion to anything considered 'mathematics' that adults do (Korelek, 2009). Children engaging with activities through play will use mathematical understandings and ideas as part of that play (van Oers 2016). Although English (2016) considered children from preschool (ages beyond the focus of this paper), her points are relevant here, particularly her description of children's willingness to engage with mathematics as a "natural eagerness" (p. 1081). She proposed that it needs to be recognised that young children are able to engage with mathematical ideas and that their mathematical understandings need to be revealed and built on. Meaney (2016) reiterated the idea that young children can engage in mathematical ideas, but also argued that the focus on the theories of Piaget and Vygotsky to emphasise thinking (over children's actions with their bodies) encourages a deficit model. She suggests that adults need to be wary of focusing only on children's language, rather they should also consider children's actions, as "emphasising the importance of language in learning has tended to position toddlers, with limited language fluency, as insufficient human beings" (Meaney, 2016, p. 23).

Bates, Latham, and Kim (2013, p. 1) state that "powerful emotions surrounding the application of math skills" can impact on an individual's willingness to engage with mathematical ideas, whether formally in a classroom situation or informally in everyday life. Adults' own experiences with mathematics, and the anxieties that may be associated with it, could prevent them from noticing the mathematics that is evident in young

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children's lives and the excitement with which young children engage with that mathematics (Korelek, 2009). Lee and Ginsburg (2009) stated that adults might not engage young children with mathematics due to their own fear of mathematics and "their own unfortunate encounters (and subsequent low feelings of competence) with mathematics" (p. 38, parenthesis included in original). Korelek (2009) stated that adults need to "notice, value, and build on children's excitement as they explore mathematics from the earliest age" (p. 10), and that they may need to sideline their past experiences regarding mathematics to enable them to do so.

Young Children Engaging with Mathematics

Young children engage with mathematics to make sense of the world. Bjorklund (2018), in her discussion of her earlier research from 2007 and 2008, described young children (toddlers) mathematising or making sense of the situation through the use of mathematics – that is, "sense making of mathematical relationships" (p. 41). Toddlers are able to engage in mathematical thinking during play. Garvis and Nislev (2017) identify opportunities for mathematical play to engage children's curiosity, show mathematics as a social activity, and make mathematics relevant in the child's everyday life and that of their family. They also indicate that the enjoyment children experience when engaged in play has a positive impact on children's mathematical learning.

Geist (2009) described a range of activities that infants and toddlers might engage in that involves mathematics. These activities include dumping blocks out of a bucket and moving the blocks of one colour to a separate pile, playing musical instruments, placing containers of different sizes inside each other, slicing fruit for snacks, crawling through larger objects such as boxes, and using water or sand to fill and empty containers. All the aforementioned activities would be familiar to educators and parents, but the mathematical opportunities may not be as well understood. Geist (2009) indicated possible mathematical thinking that the young children may have with whilst engaged with these activities, including classification, quantity, representational thought, identification and comparison of attributes, ordering and sequencing, and spatial relationships.

Johansson, Lange, Meaney, Riesbeck, and Wernberg (2016) analysed eight hours of video taken at a Swedish preschool. They used Bishop's (1988) six mathematical categories as a frame to analyse what was evident in the video. They also described the activities as either including mathematics in an incidental way (instrumental) or focusing on mathematics (pedagogical). If just the activities described as instrumental are considered, it was evident that all six mathematical categories were present in the videos, including some instances where more than one mathematical category was evident in one activity. The range of Bishop's mathematical categories that were identified and the instances where more than one of the mathematical categories was present, could indicate that children willingly engaged in mathematical ideas without the targeted input of an adult.

Meaney (2016) focused on toddlers' engagement with locating and proposed that the supposition that language is needed to engage with mathematical ideas is inaccurate. Videos of two children demonstrated problem solving involving locating, specifically, climbing on a bench and over a play frame. Each of these activities involved the child physically moving their whole body in relation to the objects and both children were able to successfully negotiate their movements with the objects. Meaney (2016) concluded that the toddlers were able to "learn about locating themselves in space" (p. 23) using actions to lead to learning.

Palmer, Henriksson, and Hussein (2016) outlined the mathematical ideas evident in the routine of changing nappies. A range of mathematical ideas were present in the observations, including counting, weight, volume, spatial orientation, time, size, and proportion. However, Palmer et al. (2016) found that there was great variety in the terms used for mathematical ideas that were observed by the educator - not all educators recognised the range of mathematics evident in this frequent activity.

Lenses for Identifying Young Children's Mathematics

Phillipson, Sullivan, and Gervasoni (2017) provided neurological and biological research to supplement the work of educational theorists Piaget and Vygotsky to draw a link between the impact of learning and learning opportunities during children's early years and progress in later years. This, they propose, highlights the importance of the role of families in early childhood learning and provides emphasis on how "families (and educators) can engage with children in ways that will promote early mathematical development (p. 8). Three 'lenses' are described below to demonstrate how the mathematics in the activities young children engage with can be made visible to adults. They each describe a way to focus on mathematics but differ in both the focus and how the focus can be used by the adult to make visible and accessible the mathematics young children engage with. To illustrate the use of these lenses, examples are included from the literature used above to describe how young children can engage with mathematics in their early years.

The activity - Bishop (1988)

Bishop (1988) described six fundamental mathematical activities as universal, "in that they appear to be carried out by every cultural group … and are also necessary and sufficient for the development of mathematical knowledge" (p. 182). The six mathematical activities are counting (for example, numbers), measuring (such as comparisons and units), locating (incorporating position and orientation), designing (for example, properties of shapes and objects), playing (incorporating rules, procedures, and processes), and explaining (such as classifications, generalisations, and explanations). Bishop (1988) stated that the inclusion of more than one of these activities would provide greater significance due to their interaction. He proposed that these six mathematical activities could be used as a structural framework to enable engagement with mathematical ideas. With young children, a consideration of the activities they engage in as part of their everyday actions, and a deconstructing of these, could enable the mathematics involved to become visible.

Johansson et al. (2016) used Bishop's (1988) fundamental mathematical activities in their analysis of the mathematics children can engage with and which "forms the children's experiences and interests" (p. 28). All six of Bishop's mathematical activities were evident, and the authors stated that there were instances where more than one of Bishop's mathematical activities could be seen to be present. Also of interest is that Bishop's mathematical activities were present in those instances described by the authors as instrumental, where "mathematics was incidental" (p. 29) and not the main focus.

The mathematical components - Greenberg (2012)

Greenberg (2012) used five mathematics components to identify and discuss mathematical opportunities and involvement. The mathematics components are number and operations (such as quantities and counting); shapes and spatial relationships (identifying objects, shapes, and positioning); measurement (incorporating qualities); patterns, relationships, and change (including recognising and creating repetitions); and collecting and organising data (such as collection and analysis of information). She proposed that the use of these components would increase the awareness of mathematics in everyday routines, enabling the identification of mathematics in everyday environments, both to discuss and to extend mathematical engagement. It could be that with young children, the identification of these components in their everyday happenings may enable the recognition of the mathematics involved.

Geist (2009) described eight examples of activities infants and toddlers might engage with and identified the mathematical components that could be evident. Although published before Greenberg (2012), the process used by Geist reflects how Greenberg's focus on components could be used to identify the mathematical thinking young children engage with. Geist emphasised the importance of educators *actively observing* what infants and toddlers do to enable the identification of mathematical components.

The language - Platas (2017)

Platas (2017) focused on the vocabulary as a way of identifying the opportunities for developing mathematical ideas. She recognises that mathematical understandings have been developed through both informal and more targeted supportive environments that provide opportunities that encourage "sustained engagement and positive interactions" (p. 34). Platas (2017) described teacher maths talk, which considers the vocabulary used and the questions that could be asked to develop mathematical ideas during interactions in the learning environment. Although the focus of the paper was on teacher maths talk and the aim of the paper was to encourage children's use and understanding of mathematical words and language, the recognition of language that is mathematical in what children say and in describing what children are doing may assist in the identification of mathematics young children are engaged with. This wider consideration of the language young children and adults use to engage with and describe what children are doing reflects the of the fact that young children do not always need to use language to be engaged with mathematics (Johansson, Lange, Meaney, Riesbeck, & Wernberg, 2014).

Palmer et al. (2016) recorded language involved in the everyday routine event of a nappy change at a Swedish preschool. The mathematical content of the utterances on the recordings was analysed and allocated to mathematical categories. What was noted by the authors was that mathematical ideas were not always verbalised by the educators. However, what was not noted is whether the educator chose not to verbalise mathematical ideas or whether the educator could not see the mathematical ideas. It may be that the mathematical ideas were not noticed by the educator (Cohrssen & Tayler, 2016; Korelek, 2009) and therefore not commented on or the educator did not take the opportunity to verbalise the mathematical ideas (Platas, 2017).

What is argued for?

This paper is not arguing for a formal academic curriculum with a focus on mathematical instruction (Elkind, 2012) to develop mathematics, but for a heightened awareness to create the opportunities for young children to revel in their "natural eagerness" (English, 2016, p. 1081) and participating adults being able to identify the mathematical ideas that may be present in everyday events (Geist 2009). However, this requires adults who are able to recognise and encourage the mathematics concepts that children are using. The lenses in the previous section can provide support for adults in identifying the mathematical ideas young children engage with in their everyday, spontaneous, and curiosity-driven lives.

Before educators, caregivers, families, and the general community can engage young children with mathematics, opportunities for adults to re-think or re-vision how they see and engage with mathematics needs to occur. Lee and Ginsburg (2009) identified nine misconceptions that early childhood teachers and preservice early childhood teachers held regarding young children's engagement with mathematics. One of these, that "young children are not ready for mathematics education" (p. 38), illustrates adults may not consider focusing on mathematics with young children. The eight other misconceptions that were identified would serve to limit the mathematics that children engage with or how they might engage with mathematics. The beliefs and attitudes, and potential misconceptions regarding the capacity for young children to engage with mathematics, has the potential to impact on what early childhood educators do regarding young children and mathematics (Sayers, 2013). In a similar way, parents and caregivers may not want to engage young children in activities involving mathematics (Koralek, 2009) or to recognise the mathematics involved in what young children do in their everyday lives (Palmer, et al. 2016).

The first step for adults not involved in early childhood education, would be the realisation that young children do engage with mathematical activities and mathematical thinking and that these activities and thinking are wide and varied. The use of any of the three lenses provided earlier in this paper (Bishop, 1988; Greenburg, 2012; Platas, 2017) would enable mathematics to be made visible to the adults engaged with young children. Bishop (1988) highlights how the engagement with the six universal activities is sustained and focused, reflecting the eagerness described by English (2016). Greenberg (2012) explained how mathematics is evident in everyday activities with infants and toddlers and that they are capable of using mathematical ideas and concepts to make sense of their world. She outlined that adults need to become aware that everyday activities involve mathematics and that the language used is highly mathematical. Likewise, Platas (2017) provided a range of mathematical vocabulary and questions which could be used in everyday contexts and activities. These would assist an adult to recognise and engage with the mathematical thinking of young children, reflecting what Meaney (2016) argued for - a "focus more on what young children can do and how this might provide insights" (p. 5).

Thornton (2018) describes the importance of mathematics in early childhood as "fostering intellectual curiosity" (p. 276) and providing opportunities for children to experience positive emotional responses such as delight and joy. Enabling adults to *see* the mathematics that young children engage with could open opportunities for adults to extend this engagement through conversations and questions. Geist (2009) provides many examples of descriptions, statements, and questions that can be used with young children to "encourage the natural mathematical interests" (p. 39). Likewise, Platas (2017) provides a range of questions that can encourage children to think mathematically within the context of their everyday activities. Although some of these questions are overtly mathematical, the contexts in which they can be used would are closely linked to the children's everyday lives, enabling them to "describe our world mathematically" (p. 34).

There is the risk that once adults realise that young children can engage in mathematical thinking, they will push for more formal educational experiences for young children. Elkind (2012) warns of the risk of moving the focus of early childhood education to formal academic instruction. He proposes that a focus on academic instruction might emphasis rote-based or formal educational curricula, which could value knowing instead of understanding. This could also lead to a move away from children initiating their activities due to intrinsic curiosity to educators using (or imposing) activities with "very little challenge, interest, or novelty" (p. 86). These experiences might then build to reflect those that disengaged the educator might have developed from their learning of mathematics, such as their perceived low confidence (Lee & Ginsburg, 2009) or their fear of mathematics (Bates et al., 2013), repeating history and condemning further generations to mathematical disengagement.

Lembrér and Meaney (2014) highlight the risks of schoolification, particularly in terms of whether the child is viewed as lacking mathematical knowledge, instead of bringing mathematical understandings with them. This could be a more negative interpretation of Kinnear and Whittmann's (2018) "mathematical potential (p. 20) – although they have potential, young children also have current mathematical understandings. Lembrér and Meaney (2014) also warn of the risk of changes in the mathematical activities an educator may create, based on schoolified curricula and expectations. Lembrér (2015) continued this point, proposing that schoolification could lead to mathematical focused activities selected for young children (potentially those such as described by Elkind), rather than having the opportunity engage with mathematics through play (Garvis & Nislev, 2017) and natural curiosity (Thornton, 2018).

Conclusion

Early childhood is an age when initial engagement with mathematics occurs. Young children's engagement with and making sense of the world necessitates the use of and development of mathematical thinking (Bjorklund 2018). Play experiences also involves mathematical thinking (Garvis & Nislev, 2017). Unfortunately, adults do not always see the mathematics involved or recognise the capacity of young children to willingly engage with mathematical ideas.

Early childhood educators struggle to recognise mathematics in the activities of young children. This may be due to their personal mathematical experiences which in turn, can impact on their capacity to identify mathematical opportunities in activities children engage with (Anders & Rossbach, 2015). However, early childhood teacher education courses do challenge and change early childhood preservice teachers' beliefs and attitudes towards mathematics and teaching and learning mathematics for young children (Cohrssen & Tayler, 2016). Kinnear, Lai, and Muir (2018) highlight the importance of cohesion between the learning environment and the mathematical understanding and knowledge held by the educator. This has moved from acknowledging that children can engage with mathematics to a consideration of the "ethical obligations to provide mathematically purposeful environments where young children can make sense of mathematics and develop their mathematical thinking (Kinnear, Lai, & Muir, 2018, p. 2), though these should heed the advice of Elkind (2012) and Lembrér and Meaney (2014).

The engagement with families is also being embraced, with Phillipson et al. recognising the contribution of the family to the child's development of mathematical understandings. As with educators, adults in families need to be able to identify and recognise mathematics in their everyday lives and contexts. Families need to be provided with support to enable them to identify the mathematical understandings evident in their children's everyday experiences (Greenberg, 2012). Bjorklund (2018), Geist (2009), Meaney (2016), Palmer et al. (2016), and Garvis and Nislev (2017) all described the mathematics that may be evident in everyday activities that families might experience with young children. These are all opportunities waiting to happen that will enable children to reach their “mathematical potential” (Kinnear & Whittmann, 2018, p. 20) with their “natural eagerness” (English, 2016, p. 1081).

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