Developing curiosity in the classroom: The case of the four triangles

Ems Lord, Director of NRICH

University of Cambridge

In our increasingly crowded curriculum, nurturing mathematical curiosity could be easily overlooked in the classroom. This paper reports the findings from an ongoing NRICH project addressing the scarcity of curiosity in many of our classrooms. Through the lens of a geometric classroom activity, it explores the extent that primary-aged learners are able and willing to work in a curious manner. This paper draws upon both teacher interviews and focus group discussions with the learners. It reflects on the obstacles towards embedding a culture of curiosity in our schools and suggests possible avenues for further investigation.

Curiosity, teacher development, shape and space,

Background and literature

In our increasingly automated environment, future citizens should develop flexible problem-solving skills (OECD, 2018). Nevertheless, existing school curricula and their accompanying assessment regimes tend to reward knowledge rather than skills. Some researchers have called for schools and policy-makers to recognise the changing needs of learners, identifying a list of attributes known as Habits of Mind (Cuoco, Goldenberg & Mark, 1996). NRICH (a mathematics outreach project based at the University of Cambridge) focuses on the four attributes of resilience, thinking mathematically, working collaboratively and being curious. This paper reports on NRICH's recent work addressing curiosity.

The term 'curiosity' has its roots in the Latin *curiosus* which refers to the act of being inquisitive or having an eagerness to learn. Litman (2005) regarded curiosity as "a desire to know, to see or experience that motivates exploratory behaviour directed towards the acquisition of new information" (p. 793). More recently, Engel (2015) described curiosity as "an expression, in words or behaviours, of an urge to know more" (p. 16). Although the literature review revealed an extensive body of knowledge discussing mathematical curiosity, there was a scarcity of research-informed classroom resources for nurturing mathematical curiosity. NRICH addressed the following research question: "How can we support teachers to nurture mathematical curiosity in their classrooms?"

Reflecting on the above definitions of curiosity, it appeared that curiosity required learners to create new learning for themselves through a range of experiences and a willingness and ability to ask questions. From these different aspects, the following five themes emerged for nurturing curiosity:

Noticing – describes what they see, which may involve describing a shape or a pattern, may need prompting

Wondering – asks questions about what they notice, typical comments might include 'I wonder if…'

Investigating – follows up one of their questions by investigating it further, such as checking their prediction about the next number in pattern
Reflecting – talks about how they went about their task, considers alternative approaches and considers ways to approach a similar problem in the future
Creating –may make their own pattern or devise a similar problem for others to solve.

These five themes were extensively discussed in the literature yet their capacity for nurturing mathematical curiosity in the classroom appeared unknown. Hence this project adopted a pragmatic approach towards addressing the research question, reflecting the belief that knowledge was "an instrument that guides action" (Hartas, 2010, p. 41).

Method

Working with two pilot primary schools (one urban, one rural) and a panel of 20 teachers drawn from across the UK, the five themes and a set of accompanying resources were trialled and the feedback from the teachers informed their review, then a revised list of themes were presented to a second panel of 61 primary mathematics subject leaders for further scrutiny.

An NRICH team member visited the two pilot primary schools to introduce the teachers to the five themes and a selection of accompanying activities for their classes to explore. which included the Four Triangles Puzzle (Figure 1). The teachers were encouraged to experiment with different ways of using the themes with the resources over a period of several weeks. During a follow-up visit, feedback was collected from the teachers and focus group interviews were conducted with groups of their learners. encouraging them to reflect on their experiences using the materials and their own mathematical curiosity. The data was analysed using framework analysis (Richie & Spencer, 1994). First, the interviews were typed up, then they were read and re-read before coding them to identify key themes in the feedback. The teachers also provided samples of classroom work using the activities and the five themes.

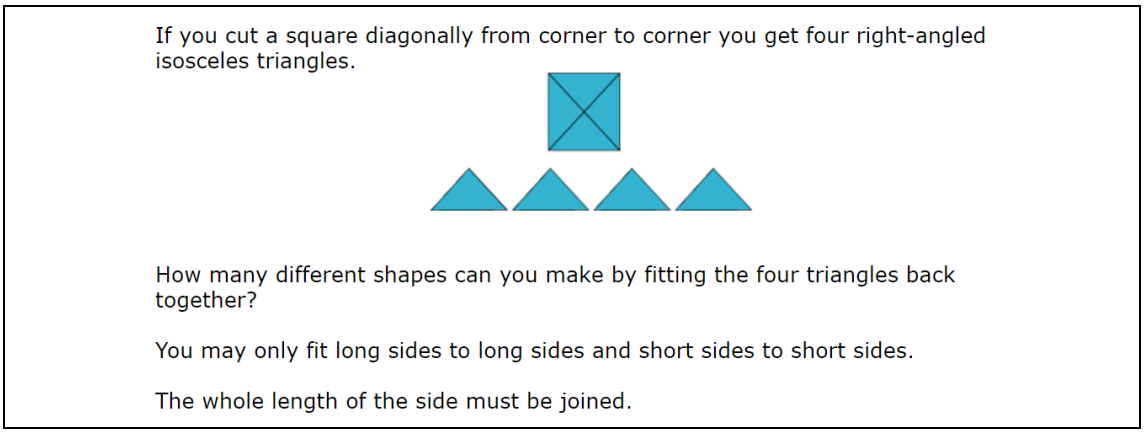

Figure 1
The Four Triangles Puzzle

As mentioned above, the five themes were also reviewed by a panel of 20 teachers during a professional development (PD) day. Working in pairs, one teacher attempted the puzzle while their partner recorded their observations on grid featuring the five themes (Figure 2). Then each pair of teachers was asked to share their feedback which was analysed using framework analysis. The findings from both the pilot schools and the PD day informed the following revised list of themes which reduced the original list to four themes by combining 'Reflecting' and 'Creating':

> *I notice that*…Say what you see. Is there a pattern? What's the same, what's different?
> *I wonder if*…What might a mathematician ask? Or an artist? Or your teacher?
> *I'm going to investigate*…What will you investigate first? Why? How will you get started?
> *Reflecting and creating*…What helped you to solve this problem? What didn't help? What else could you have tried? Suggest a hint for another class. Try changing one thing to create your own problem. What else would you like to investigate?

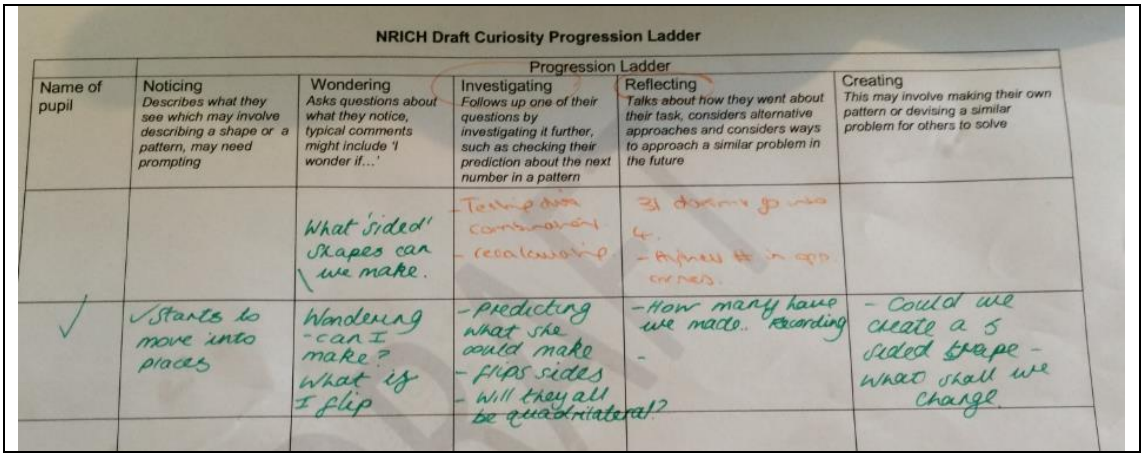

Figure 2
Using the five themes to record observations addressing curiosity
Note. The green ink refers to observations relating to the Four Triangles Puzzle.

Finally, the revised list of four themes was scrutinised by a teacher review panel consisting of 61 primary mathematics subject leaders attending one of five different PD events. After being introduced to the aims of the overall project, the four themes and using them during a paired activity during their event, they were asked to rate their relevance and clarity which gave an indication of the validity and reliability of the themes for nurturing curiosity. The teachers were also asked to share any comments which supported their scoring. Beginning with relevance, over 90% of the teachers rated the themes as 'relevant or very relevant' for nurturing mathematical curiosity in their classrooms. This indicated a high degree of validity for the selection. Several teachers commented that the wording accompanying the themes supported the development of curiosity. For example, "I think the questions are good for developing curious learners – I think it will challenge them. They will think more about things – talk about learning." Another teacher suggested that the themes "Could be useful as a

planning tool to develop questions and might be useful for a TA [teaching assistant] during guided group work." For clarity, over 80% of the teachers rated the themes as 'clear' or 'very clear.' This indicated a high degree of reliability for them. "The headings make good prompts to guide the children through their thinking," noted one of the teachers. "It's a good framework to scaffold the curiosity and promote deeper thinking," responded another teacher. Some of the respondents suggested developing different versions for younger learners as well as specific versions of the themes for teachers and their classes. Another teacher suggested that the choice of themes were a "really great resource and I can't wait to use it for a specific child."

Findings

The in-school interviews and feedback from the PD events revealed the importance of considering several key aspects of nurturing curiosity and maximising the potential of the four themes in the primary classroom. Each of these points is explored in more depth in this section, beginning with findings relating to mathematical topics.

The potential impact of different mathematical topics on the curiosity of learners

It appeared that certain mathematical topics were more suitable for nurturing curiosity than others. Focusing on the Four Triangles Puzzle, some of the teachers drew attention to its geometric nature and hence its perceived suitability for harnessing curiosity in the classroom. Those teachers felt that many learners held negative attitudes towards number and calculation work, which was detrimental towards nurturing curiosity through those topics. They felt that by focusing on a mathematical strand away from number and calculation work, such as geometry, they increased the potential of their lesson for stimulating mathematical curiosity. Moreover, by encouraging their learners to actively engage with the activity by moving shapes, either manipulating cut out paper triangles on their desks or accessing an onscreen interactive version, the teachers felt that the activity further stimulated curiosity in their learners.

The most effective ways to present an activity to stimulate curiosity

The teachers felt that it was very important to consider how the learners were introduced to the activity. They reported that presenting the learners with either a picture of four triangles, or their own examples, before introducing the challenge appeared to be a more effective approach which made strong links with the themes. This approach enabled teachers to ask their learners what they noticed about the shapes, allowing time for discussion, before moving on to consider what they would like to investigate further. One of the teachers shared their preferred way to focus their learners on the different types of questions that could be asked by challenging them to think of questions that "a mathematician might ask, or an artist or a teacher" and a similar approach was added to the descriptions of the themes in the revised version.

The benefits of using 'low threshold-high ceiling' resources for nurturing curiosity

The teachers stressed the importance of using low threshold, high ceiling (LTHC) activities for stimulating mathematical curiosity. LTHC activities are designed to be

accessible to most, if not all learners, because the mathematical content is relatively simple, yet offer opportunities for learners to extend their thinking and reasoning skills through the choices they make. The teachers felt that the puzzlewas a LTHC activity since most, if not all, of their learners could rearrange the four triangles to create another 2D shape. For example, one teacher noted that their learners were "All trying and quite resilient, happy to experiment." One of the learners commented, "This reminds me of science because we are experimenting with the shapes." The benefits of the perceived 'high ceiling' of the activity came later in the session when the same teacher noticed that, once the learners had produced several shapes using their four triangles, "they started to get repeated shapes which had been rotated." The group of learners realised that they need to established rules regarding whether rotations of shapes should be accepted as answers (Figure 3).

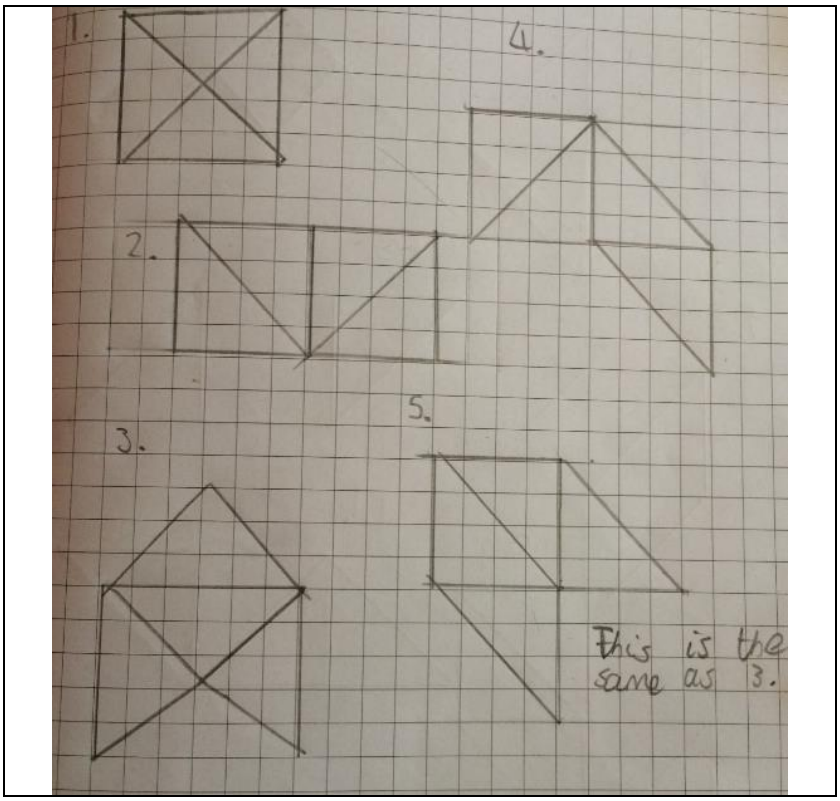

Figure 3
Example of a learner's work showing repeated shapes

Maximising the potential of the themes

As part of the piloting process, the schools were asked to explore using the themes in different ways. One of the teachers trialled sharing the themes with their learners; each member of their class was given their own copy of the themes which was glued in the front of their exercise books. After working on a curiosity activity, the learners would reflect on learning and identify their next steps. At first, their teacher reported that the class tended to rely heavily on simply copying out their learning objective. Over time, the teacher felt that the learners became more confident and began to take ownership of their learning by expressing a desire to progress to another theme. In the subsequent focus group interviews, the learners confirmed that the themes enabled

them to set targets for their future learning. Their teacher felt that this was a worthwhile experiment and planned to introduce the themes across the school for the older learners, noting that the addition of illustrations might make the themes more accessible for younger learners and EAL learners too.

Discussion

Although the literature review revealed a scarcity of existing resources for nurturing mathematical curiosity in the classroom, teacher feedback from this project indicated the potential benefits of using the four curiosity themes in schools alongside resources designed to stimulate curiosity. These benefits included revealing the curiosity levels of each cohort, enabling schools to reflect on their current provision for nurturing curiosity and reflecting on their results for future whole-school planning, and allowing learners to take responsibility for their own learning by encouraging individuals to reflect on their existing curiosity skills and set their own future targets. By encouraging teachers to experiment with different ways of using the themes in their classes, their potential as a tool for learners as well as their teachers, was revealed. However, ensuring that a wide range of learners could access the themes in the future will require presenting them in different versions for younger and older primary-aged learners.

The findings also revealed that teachers believed that topics such as shape and space were ideally suited for curiosity work, perhaps more so than number and calculation, hence the development of future curiosity resources could target those aspects of the curriculum.

References

Cuoco, A., Goldenberg, E. P., & Mark, J. (1996). Habits of mind: An organizing principle for mathematics curricula. *The Journal of Mathematical Behavior*, *15*(4), 375-402.

Engel, S. (2015). *The hungry mind*. Harvard University Press.

Hartas, D. (Ed.). (2010). *Educational research and inquiry: Qualitative and quantitative approaches*. London, England: A&C Black.

Litman, J. (2005). Curiosity and the pleasures of learning: Wanting and liking new information. *Cognition & emotion*, *19*(6), 793-814.

Organisation for Economic Co-operation and Development (OECD). (2019). *Trends Shaping Education 2019*. OECD Publishing, Paris. Retrieved from https://doi.org/10.1787/trends_edu-2019-en.

Richie, J., Spencer, L. (1994). Qualitative data analysis for applied policy research. In A. Bryman & R. Burgess (Eds.), *Analysis of qualitative data* (pp. 187-208). London, England: Routledge.