The important things about writing in secondary mathematics classes

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A children's book is used as a stimulus for a mathematical writing activity.

Many mathematics education associations worldwide, such as the Australian Association of Mathematics Teachers (Neal, 2007) and the National Council of Teachers of Mathematics (2000), have recommended incorporating literature, writing, and/or literacy into mathematics classes. Literacy is one of the general capabilities of the *Australian Curriculum* (see https://www.australiancurriculum.edu.au/f-10-curriculum/generalcapabilities/). Such integration helps students to make connections between subject areas, see mathematics as real-world applicable, increase their understanding of concepts, and become more engaged in learning mathematics (Connelly, 2005). Integration also helps generalist teachers to meet curricular demands for multiple subject areas, which is particularly important due to the dense nature of academic curricula. Furthermore, using writing assignments in mathematics classes allows students to demonstrate their understanding in a different way and provides teachers with a different manner of accessing and assessing students' understanding.

Several examples of activities and assignments involving writing in mathematics have been shared in practitioner and research literature. Often, the examples focus on mathematical communication (i.e., clearly communicating one's understanding of a mathematical topic) rather than a rich cross-curricular exploration of concepts and skills from English/literacy integrated with those from mathematics. For instance, suggestions for writing in mathematics class include having students make their own mathematics dictionaries, writing journal reflections in response to prompts at the end of class, and composing mathematics autobiographies (Downey, 1995; Hot ideas: Writing in Maths, 2009).

There are many examples of activities involving the use of storybooks in pre-school and primary mathematics contexts. Storybooks have been found to bridge the gap between passive and active forms of mathematics learning; increase students' motivation, engagement, and memory; connect mathematics content to relatable life experiences; develop mathematical proficiencies; and clarify students' mathematical misconceptions (Columba, Kim, & Moe, 2005; Skoumpourdi & Mpakopoulou, 2011).

Teachers may choose to incorporate books with explicit or implicit mathematical content. The main purpose of books with explicit mathematical content (by authors such as Marilyn Burns, Stuart Murphy, and Greg Tang) is the mathematics; the story is wrapped around the mathematics. These books may inspire children who like mathematics but who do not like to read. In contrast, books with implicit mathematics content focus on the story; the mathematics is incidental and therefore may help to draw reluctant students

into mathematics. Examples of such books include *A Chair for My Mother* (Williams, 2007) and *The Important Book* (Brown, 1949).

Incorporating writing, literacy, and/or storybooks into mathematics class has been shown to increase students' engagement and understanding. Instances of such integration tend to be limited to the primary school or pre-school context. At the secondary school level, students' experiences with mathematics are typically staid and devoid of creativity. Limin, who teaches mathematics education classes to secondary pre-service teachers, wanted to challenge students' typical experiences with secondary-level mathematics. She was inspired to incorporate a storybook-based activity into her pre-service teaching that used Margaret Wise Brown's *The Important Book* (1949), and was similar to two examples that took place in primary school mathematics classrooms. In the first example (Bertheau & Theissen, 1994), students in a third-grade class in the U.S. created their own version of *The Important Book* about shapes, as part of a larger unit of study about geometric properties of 2D shapes. Students had to decide on the "most important thing" about their shape, based on their own knowledge of the shape's attributes. They also conducted interviews with family members to gain a wider perspective on the shape. In the second example (Whitin & Piwko, 2008), a similar activity occurred. Third-grade students selected a geometric term and wrote a poem about the properties of the shape. As in the first example, students were encouraged to interview family members about their chosen shapes. Both examples were reported as being successful in terms of learning and engagement.

Limin thought that the activity would also work well with more advanced mathematical content, with mathematical topics outside geometry, and with older students. Thus, she used a similar activity with the secondary pre-service teachers in her mathematics education class to see if the activity would promote engagement and mathematical understanding of a wide range of secondary-level mathematics concepts.

Context

The secondary pre-service teachers were students in a masters-level teacher education program in central Canada. The mathematics methods unit was part of their two-year program. The purpose of this unit is to introduce pre-service teachers to teaching approaches and the role of the teacher in implementing and evaluating mathematics curricula for students in upper middle school and secondary school (Years 7–12). The unit is structured around pedagogy- and content-based themes (e.g., social justice, technology, probability, algebra). In a class focused on the use of literature in the mathematics classroom, students were tasked with creating their own version of *The Important Book*.

The Important Book activity

To begin the activity, the instructor, Limin, read out loud *The Important Book* in its entirety. Then, she asked the pre-service teachers about their impressions of the book and to comment on the structure of each page. Pre-service teachers easily recognised that each page focused on a topic (e.g., grass) and that each line described a characteristic of the chosen topic (e.g., It is green; It grows). They also noted that the first and last line on each page followed the pattern: "The important thing about ___ is…" and "But the important thing about ___is…", where the characteristic listed in the first line was repeated. Limin then invited the pre-service teachers to each create their own page (describing

a mathematics concept) to contribute to their version of *The Important Book*. They were given one week to complete their contributions and post them to the unit website.

Pre-service teacher work samples

In this section, we present a few samples of the pre-service teachers' work to give the reader a sense of what they created. Then, in the following section, we discuss common features of the pre-service teachers' work and elaborate on their collective response to the activity. All names are pseudonyms.

The important thing about the quadratic formula is the discriminant

by Justin

The important thing about the quadratic formula is the discriminant.
The discriminant tells you about the roots,
Whether there's zero, one, or two.
Remember $b^2 - 4ac$,
A simple test for functions of second degree.
The rest of the formula works well on occasion,
Plug it all in to solve the equation.
Behold! From function to root without a tear,
Next time your teacher asks, you'll volunteer.
Change a, b, or c, and the roots will be different,
Make one wrong move and they'll be nonexistent.
But the important thing about the quadratic formula
Is the discriminant

Trigonometry

by Emily

The important thing about trigonometry is that it is about triangles.
It's about all different kinds of triangles: right-angled, scalene and isosceles.
Don't worry you'll figure it all out and start solving problems with ease.
Right-angled triangles are special, three ratios are key.
Sine, Cosine and Tangent will get you the answer, I'm sure you will soon agree.
SOHCAHTOA is what is important, you will see.
Opposite, adjacent and hypotenuse—use the right ones and you will get the right answer, I guarantee!
But, if it is not a right-angled triangle that you have, you will have to pause...
Since you will need the Sine and Cosine Laws.
Sometimes it may seem like your solution is in mangles,
But the important thing about trigonometry is that it is about triangles.

Important thing about angles

by Faiz

The important thing about Angles
Is that they're everywhere
Acute, Obtuse, Right, or Reflex
They're all around you
Even if you don't care

Supplementary in a pizza you cut
into slices to share
They add to 180° together
But not necessarily equal.
Though they can be if you wanna be fair!
Alternate & Corresponding are similar
but draw a Z and F
if you want to compare
From shapes like octagons, triangles, and squares
To a room with walls, doors, windows, and chairs
You'll find complementary with a sum of 90°
Opposites are equal and well...opposite
and always in pairs
So if ever if you've got a moment to spare
Look around you and soon you'll be aware
That these angles are not so rare
From the branches of a tree to the
Snowflakes in the air
So really, the important thing about
Angles is that they're everywhere.

Unpacking students' writing and experiences with *The Important Book* activity

As shown in the examples above, *The Important Book* activity allowed pre-service teachers to demonstrate their mathematical understanding, be creative, take ownership of their learning, increase their engagement, step outside their comfort zones, and build productive relationships with each other. Inherently, the activity allowed pre-service teachers to demonstrate their mathematical understanding as they were required to describe characteristics about their chosen topics. For example, Emily's contribution about trigonometry communicated her knowledge of different types of triangles ("right-angled, scalene and isosceles"), ratios found in right-angled triangles ("Sine, Cosine and Tangent"), a mnemonic to remember the ratios ("SOHCAHTOA"), and two formulae related to non-right-angled triangles ("Sine and Cosine Laws").

Pre-service teachers' mathematical communication was creative and went beyond the structure of Brown's book. Most embellished on the original pattern with contributions that were much longer. While each topic in the original book was described in five to eight lines of text, pre-service teachers' contributions ranged from 8 to 47 lines. Pre-service teachers also included literary devices in their contributions, most commonly rhyming (as shown in all the samples). Thus, the cross-curricular nature of the activity allowed them to apply skills in both mathematics and the language arts, as advocated by Austin, Thompson, and Beckman (2005).

In contrast to similar activities by Bertheau and Theissen (1994) and Whitin and Piwko (2008), students in Limin's class were allowed to select their own mathematics concept, rather than being limited to geometric terms (namely 2D and 3D shapes). As such, there was a wide range of topics chosen. The open-ended nature of the writing activity allowed pre-service teachers to take ownership of their own learning. It is reasonable to suggest that they selected topics that were of personal interest to them,

about which they wanted to learn more, and/or about which they felt confident in their existing knowledge. Additionally, this open-ended activity provided an opportunity for pre-service teachers to go beyond the confines of prescribed curriculum and enrich their mathematics learning. For example, in his contribution about curves, Mahmoud included hyperlinks to different pages on the *MacTutor History of Mathematics* archive (http://www-history.mcs.st-and.ac.uk/) to explore various curves (e.g., trisectrix of Maclaurin, double folium), allowing himself and the reader to delve into content beyond the secondary mathematics curriculum. Such writing further illustrates the potential of open-ended, 'low-floor, high-ceiling' tasks as a way for students to deeply engage with mathematics (Gadanidis, 2012).

Benefits of *The Important Book* activity were not limited to completing the task itself. Pre-service teachers continued to engage with the activity through the unit website and in future classes. The unit website had many features to allow them to interact with one another. They could post responses to their peers' contributions and/or click on the 'like' button (similar to Facebook) for specific posts. The unit website served as a space for the instructor and pre-service teachers to share ideas, responses to class content and activities, and teaching resources. Although members of the class had posted on the unit website earlier in the semester, it was only in response to this activity that pre-service teachers responded to or 'liked' posts, thus showing a level of mutual engagement with the activity and with each other. For example, Sylvia responded to Edgar's post, his contribution about probability titled *Maybe*. To reference the mathematical meaning of his topic, each line of Edgar's contribution (other than the first and last, in which he retained the original structure: "The (most) important thing about probability is…") started with the word 'maybe'. Additionally, Edgar used rhyming couplets throughout his contribution (e.g., "Maybe you manage your risks and get rich, Maybe you gamble and end up in a ditch."). Sylvia responded to Edgar's post with the following comment, "Maybe Edgar has risen the bar, Maybe I'll have to redo what I've written so far." Not only did they show their appreciation for each other's posts by commenting on the unit website, they also mimicked each other's creativity, thus showing mutual and ongoing engagement with the activity.

In the next class after contributions were posted on the unit website, the pre-service teachers immediately and without prompting by the instructor started discussing each other's contributions, highlighting a prolonged engagement with the activity. They enthusiastically praised one another, and excitedly discussed the content of the contributions and their mutual enjoyment in completing the activity. This response was in pleasant contrast to the trepidation, uncertainty, and slight resistance witnessed when the activity was introduced and pre-service teachers asserted that they were "not creative" or "not good at writing". Their positive reactions to their own writing as well as the positive reinforcement received from their peers no doubt strengthened their self-confidence. Additionally, the collective engagement and interaction between pre-service teachers due to the activity seemed to strengthen the sense of classroom community. Research (e.g., Green, Emery, Sanders, & Anderman, 2016) has shown that feelings of community have a direct impact on student achievement and retention, thus validating additional benefits of *The Important Book* activity.

The important things about *The Important Book* activity are…

In this article, we presented a writing activity that allowed pre-service teachers to be creative in the mathematics classroom. Inspired by *The Important Book* by Margaret Wise Brown, students explored secondary-level mathematics concepts, discussing

various attributes/characteristics of each concept through their written contributions. Although these were pre-service teachers, we argue that this activity would be equally successful in a secondary mathematics classroom. In particular, this activity can increase engagement of disengaged students, support students for whom English is an additional language or dialect (EAL/D), and address the literacy general capability of the *Australian Curriculum.*

Unfortunately, in secondary mathematics classrooms, many students tend to be disengaged. Thus, we imagine that if this cross-curricular activity were presented in a typical secondary mathematics classroom, students who enjoy and feel confident about writing but who are typically disengaged and/or lack confidence in mathematics would excel and may gain an appreciation of mathematics. Similarly, we expect that by using such activities, students who typically do not enjoy mathematics classes (and perhaps who even declare themselves "not maths people") would increase their engagement and, presumably, their understanding of mathematical concepts. This activity gives pre-service teachers the chance to explore mathematics in a creative way. Additionally, as literacy researchers have found (e.g., Robertson, Lewkowich, & Rottmann, 2010), engaging with children's storybooks provides adults with a sense of nostalgia and increases their interest, a finding that arguably would also apply to secondary school students.

We acknowledge that writing in the mathematics classroom could be a challenge for students for whom EAL/D, which is an important consideration in Australia, where a substantial proportion of students are English language learners. Yet, this activity, which focuses on mathematics content, rather than the language itself (e.g., syntax, spelling) could alleviate some of these challenges. The activity could also provide a more accessible way for students for whom EAL/D to engage with writing. Indeed, Whitin and Piwko (2008) argue that this type of activity allows for differentiation due to its open-ended nature and thus supports students who are learning English. In particular, this activity can help students for whom EAL/D to grapple with (mathematical) vocabulary, a common concern when students are learning a new language.

Integrating literature and/or writing into mathematics classrooms helps primary (generalist) teachers to effectively 'cover the curriculum' and engage students in cross-curricular exploration. While secondary school teachers are not generalists, all teachers are responsible for developing students' literacy skills, as literacy is one of the seven general capabilities in the *Australian Curriculum* (Australian Curriculum, Assessment and Reporting Authority [ACARA], n.d.-a). Specifically, the literacy general capability involves "comprehending texts through listening, reading and viewing" and "composing texts through speaking, writing and creating" (ACARA, n.d.-b). The former aspect of the literacy general capability is addressed in this activity through the whole-class reading of *The Important Book,* as well as the students' engagement with each other's contributions. The latter aspect is addressed through the students' own writing about the important aspects of their chosen mathematics topic.

But the most important things about *The Important Book* activity are…

In this article, we have presented a mathematics activity inspired by *The Important Book.* We encourage readers to infuse their own creativity into our presented activity and adapt it to suit their own contexts. One alteration could be to have students read their contributions aloud in class, as "listening also conveys insights that silent reading often does not" (Cohen, 2013, p. 536). This could also increase the level of engagement,

as students may be able to further infuse their personality/themselves into their contributions through their delivery (voice, cadence, emphasis, tone, etc.).

The Important Book activity is flexible since it can be altered to suit a wide range of year/schooling levels, mathematics topics, and students. The activity can help to engage students who are typically disengaged in mathematics classes, as well as to provide differentiated support for students for whom EAL/D. There is a wealth of research that demonstrates the benefits of using writing, literacy, and/or literature in mathematics classes, but these examples tend to come from pre-school and primary school contexts. We have demonstrated here that an activity using a children's storybook has the potential to benefit older students— in our case pre-service teachers—in their exploration of advanced mathematical concepts, and that is a very important thing.

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